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NOTES AND COMMENTS.

The Question of Terms.

Despite the wealth of the English language, a common defect of discussions on technical and general matters is a lack of definition in the terms and phrases used. Often partisans will haggle over their mutual differences, intent on showing to what length they disagree, when the simple process of defining what each means by the terms he uses would dispose of all dispute. To some extent this same trouble is evident in recent discussions on the hardness of metals and methods of testing hardness. At the Birmingham Foundrymen's meeting, reported or page 209, the term hardness appears to have been used indiscriminately to cover resistance to penetration, resistance to abrasion, machineability or resistance to a revolving drill, and resilience. Each of these properties is distinct, and though they may be associated to a greater or less extent in the same metal, they require to be determined separately. However, so long as the general term "hardness" is used to cover the lot no useful or unanimous conclusion as to methods of determining can be expected. Most people, on reflection, will probably support the suggestion put forward by Professor Turner, that true hardness is resistance to penetration. As he rightly pointed out, the first thing to do is to decide what is meant by hardness, and to define it carefully. There will probably then not be much difficulty in determining some method of measuring the property actually defined.

Another example is seen in the discussion on silicon control arising out of Mr. Adamson's paper in our last two issues. As is well known, that writer has for years been a strong opponent to grading of pig-iron by silicon contents—a system which was widely and rather loosely advocated in America and by admirers of American methods. "Silicon control," to use the vague terminology adopted, has been so impressed upon the practical man that quite a large proportion of the foundry trade still regards silicon as practically the only important variable in iron. It is all very well for the chemist and metallurgist to scoff at such an interpretation being put on the statements which have been made by "silicon control" advocates, but that is decidedly the interpretation that has been encouraged. Moreover, we have heard from even metallurgical men themselves such expressions as "the secret of cast-iron control is in the silicon."

In criticising Mr. Adamson's paper Mr. R. T. Rolfe (see page 193) deals with the contention that silicon content in cast iron does not *control* combined carbon and its ratio to graphite. He remarks:—"It is obvious that the correctness or falsity of this assertion depends entirely upon the interpretation of the word 'control.' If by controlling is meant that over a number of different irons variation in the silicon content will automatically produce a corresponding variation in the relation of combined carbon to graphite, *irrespective*

of all other variations in the conditions, then silicon will certainly not control the distribution of carbon." Without, however, defining what he himself understands by "control," Mr. Rolfe refers to Mr. Adamson's admission that "taking a given iron, under exactly the same conditions of melting, pouring and cooling, the higher the silicon the softer the iron within limits," and suggests that the latter gentleman thereby admits that under these conditions the silicon *does* produce a corresponding variation in the proportion of graphite, or, in other words, controls it.

Now all this is hopelessly confusing unless we know what we mean by control. An excess of whisky may affect a man's gait, but it does not control him unless it determines his destination and progress despite all other influences.

We agree with Mr. Rolfe that "the only logical deduction from this is that the increase of silicon in cast iron is a factor which *tends* to convert combined carbon into graphite, but the effect of which may be over-ruled by other factors, such as size of casting, temperature of casting, rate of cooling down after casting, etc." We should, however, have added to the above factors the temperature of the blast furnace and the time of contact which the reduced iron has with the other components of the furnace burden, chiefly the carbon.

The intention is not to take up the cudgels on behalf of one or other of the contending writers, but to point out the necessity of greater nicety of definition in generally-used terms. There is too great a temptation in such discussions to seek rather for apparent grounds of disagreement (often based on loose phraseology) than for grounds of common agreement; though the establishment of the latter would be more useful.

The Chemist as a Luxury.

A writer on another page makes some pointed remarks regarding the use of the chemist in the foundry, and intimates that he may prove merely an expensive luxury unless his services are properly employed. Further, however, might be mentioned the necessity of differentiating the chemist and the simple laboratory analyst. There is too often a tendency, at least in foundry circles, to regard as a chemist anyone who can conduct routine chemical analysis of metals and produce regularly statements of constituents in impressive figures of several decimal points. A man whose capacity is limited to such work may well be an expensive luxury. The chemist proper requires a much wider knowledge and training than is involved in simple chemical analysis, and if that training is broad, covering the principles of the engineering and metallurgical work associated with founding, and is accompanied by sound common sense and power of observation, he may prove, even at a high salary, one of the cheapest men in the works. So long, however, as firms expect to get—as many undoubtedly do—expert chemical, metallurgical and engineering consultants permanently in their employ for a wage of less than £100 a year, so long will there be attracted to the calling those men whose utility limits them to the class of expensive luxuries.

A lengthy discussion took place at a recent meeting of the Faraday Society upon the training and work of the engineering chemist. Ever since the war demonstrated the great importance of chemistry in the national well-being there has been a strong attempt to place chemistry upon a higher plane than has been the case hitherto in this country, and one of the fundamentals in this is a modification of the training of the chemist in order to create a new type—the chemical engineer.

The problem, of course, is one with considerable ramification, because, as Sir Robert Hadfield (who presided at the meeting) remarked, each important branch of industry demands its own special type of chemist. In handling molten metals the ferrous metallurgist often has to deal with temperatures far exceeding those met with in the ordinary chemical industry. Then the same metals have to be dealt with at quite another set of temperatures, known as "treatment temperatures," varying from 500 to 900 deg. C., and finally in some cases, when tempering, still other and lower sets of temperatures are met with. In all these the guidance and care and knowledge of the engineering chemist and physicist are necessary. Consequently, whilst there must be a common ground on basic facts relating to the training of our engineering chemists, no one routine training would cover all these requirements. This in itself, contended Sir Robert, seems to indicate that, somewhat early in his training, the student should more or less branch off into specially studying the particular lines of work with which he expects to be associated during his working career.

The foundry chemist, to be really successful, must learn as much of every branch of foundry work as he possibly can; and moreover must have a general knowledge of the conditions the casting has to meet.

Improvements in the Manufacture of Steel.

An invention for which Mr. Benjamin Talbot has recently acquired patent rights, is a development of processes protected by him in 1903 and 1904 to enable crude metal to be more or less standardised before its introduction into the furnace for the final treatment, and to effect a better refinement than is possible with the active mixer. Mr. Talbot proposes to employ two or more tilting hearths, separated by chills, but so arranged as to form practically a single furnace having separate hearths, each of which forms an active mixer and can be separately tilted, whilst the whole furnace can be worked by a single set of men.

Assuming the hearths to be empty, which would only be the case when starting the furnace, one-half is filled up as rapidly as possible by emptying into it the liquid pig-iron, and when full the filling up of the next hearth is commenced. Meanwhile the metal in the first hearth is treated as may be desired for the removal of any elements.

With this system of storage it is claimed that a considerable amount of refining can be accomplished without any hindrance to the blast-furnace plant, or delay in providng partially refined metal for the steel furnaces. Further, there is an advantage in dividing the liquid metal from the blast furnaces into separate hearths, as the refining can thus be continued and a standard product be obtained, which is obviously not possible with a one-hearth storage furnace plant, into which the metal from the blast furnaces must of necessity be delivered, although the hearth probably contains partially refined metal, thus throwing the whole charge back in both purity and temperature. Only a slight improvement in the contained pig-iron is possible in such a furnace.

Plaster Matches for Machine or Floor Moulding.

By A. Hill.

At a meeting of the Lancashire Branch of the British Foundrymen's Association recently (Mr. H. Sherburn in the chair), Mr. Allan Hill, of Heywood, read the following Paper:—

In introducing this method as one for the economical production of castings, it is with the full knowledge that it is not new, but is one that has been used for a great number of years in many foundries and on various types of castings. For some reason or other, however, it does not seem to get full consideration from foundrymen generally, when the question of cheap production is being considered. It also does not seem worthy enough to secure inclusion in the majority of text-books or trade papers, and those which do mention it generally dismiss it with a few words in an off-handed manner.

One of the best features is that any foundry, large or small, can adopt it at little cost, providing they make castings which are suitable and are made in such quantities as to warrant some method of better production, especially where the conditions do not call for the expense of making pattern plates, and also for outside orders where the patterns are supplied, as by this method patterns with only one contraction are required, thus ordinary loose patterns are suitable.

This method is one which will show a marked lower production cost from the time the matches are put into use, and, given its proper place, on its merits it cannot be lightly ignored by any progressive foundrymen, as in many instances it will be found to be the cheapest as well as the quickest way to produce good castings in quantities at a low cost, especially if they are required at short notice.

These matches may be used on most moulding machines, especially the turn-over type, or they may be used for floor moulding, as in the case of pattern plates, with unskilled or semi-skilled labour. Skilled moulders are employed in their manufacture, men used to moulding pattern plates being the most suitable, as up to a certain point the operations are similar. The material costs are not large, and, speaking generally, not much time is required for the making of the matches. In most cases they can be made, and large numbers of castings moulded from them the same day.

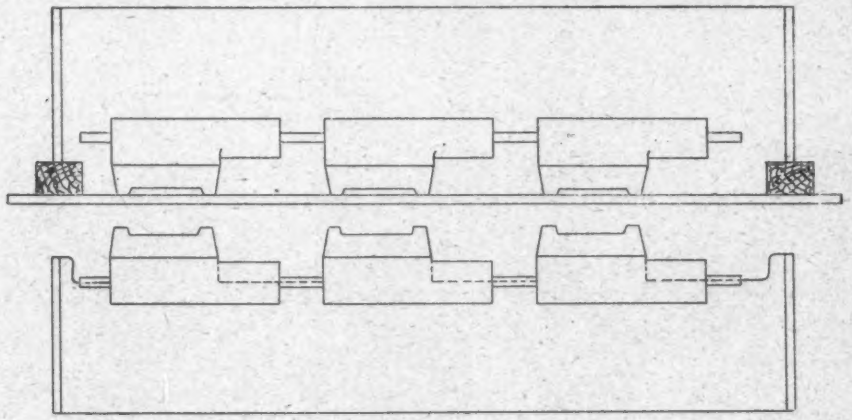


Fig. 1.

For what may be termed partial-repetition work—that is, where a large number of castings is required periodically, at intervals of may be two to twelve months, the matches are very useful; a mixed lot of castings may be mounted on one match, and if when the order should be completed it is found that there is a shortage of any particular casting, the pattern can be taken off and the number made up to what is required, afterwards replacing the pattern.

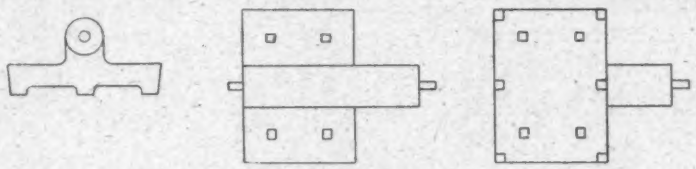


Fig. 2.

This is met with very often where a large variety of different types of machines are made. Some may be going through the works regularly, but the

majority at different periods, and in such small numbers that the expense necessary for mounting the patterns on plates would entail the laying out of a large sum of money, which would take perhaps a good number of years to regain. It is obvious though that some effort must be made to keep the working of the foundry as far as possible general; if at certain periods most of the castings are being made from plates, and at others from loose patterns, it would mean the laying off of different types of labour as the nature of the work changed.

The use of plaster matches is one method of overcoming this; instead of working patterns loose they

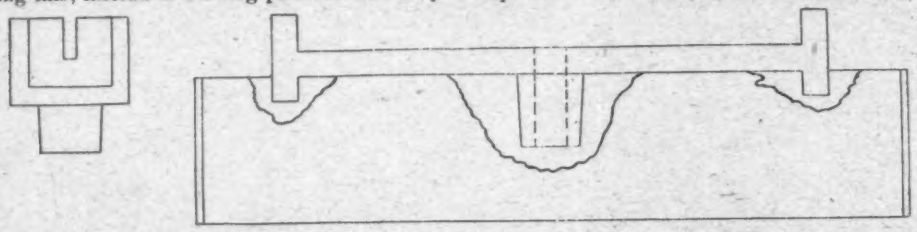


FIG. 3.

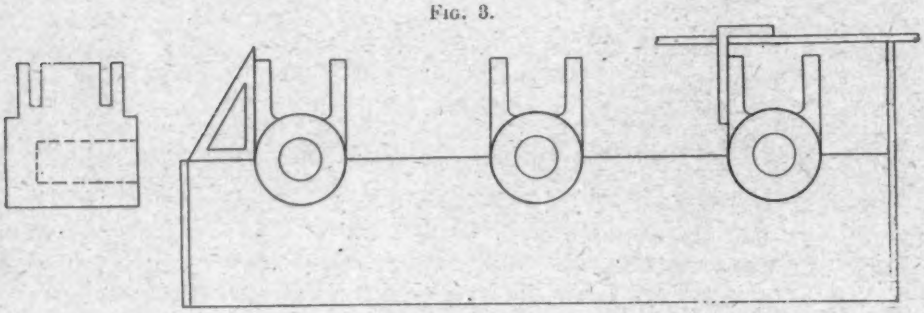


FIG. 4.

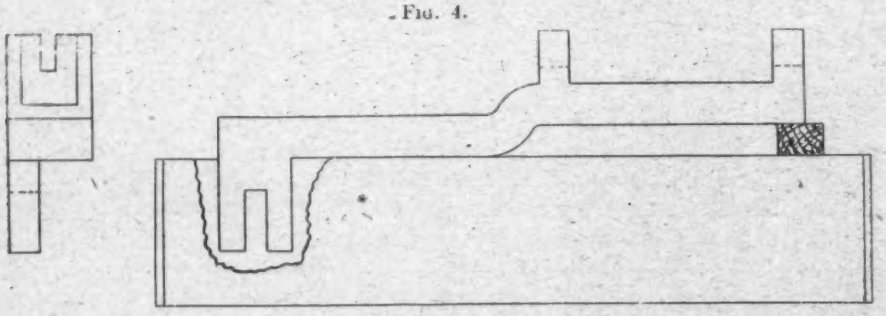


FIG. 5.

are mounted on the plaster and the castings made by plate or machine moulders thus keeping that particular class of labour (which is the cheapest) fully employed, no matter what type of machines are being made, also at the same time regulating the skilled work to some extent. They are also very useful for jobbing orders. The customer's pattern can be put on matches, and on completion of the order taken off and returned, the match being put away until further orders are secured, when the patterns are again fixed to the match as before.

For absolute repetition work or flat back patterns this method cannot be advocated as one superseding or even equalling pattern plates, except in peculiar instances, examples of which will be pointed out later.

The process of making the matches may be placed under the following headings:—(1) The setting of the patterns; (2) ramming and finishing the mould; (3) addition of protecting portions; (4) running with plaster, and (5) finishing.

After selecting the size of flask to be used and the number of castings that it will accommodate, patterns are made and prepared suitable for moulding from, that is if they are not already to hand.

The next consideration is the way in which the matches are to be used for making moulds. If for machines the flask may have to be made of such a shape and size as will suit the machine's requirements, but for floor moulding the ordinary moulding flasks can be, and are, generally used.

The first and most important operation in making the match is the setting of the patterns; some suitable means must be used so as to ensure each individual pattern being set, so as to give a good clean draw, and allow the others in conjunction to do likewise, when moulds are being made from them.

The following four methods of setting will cover most designs of castings. As will be seen they are simple and straightforward ones; in fact, the simpler the method used for this operation, the more likely is it of being successful, providing correctness can be attained by its use.

Figs. 1 and 2 show a method which can be used

for setting patterns having level surfaces or facings on the bottom side. An ordinary flat pattern plate of a suitable size for the flask selected is used, and the patterns placed in the positions required, with their level surfaces to the plate, using strips of wood of suitable thickness to raise the flask to the joint level (Fig. 1.) This part is now filled and rammed with sand, turned over, and the surplus sand cut away from about the patterns to leave an oddside, as in Fig. 2.

Fig. 3 is a pattern having a flat surface on the outside, but with a projecting boss in the centre. In this case an oddside is rammed off the plate and cut out to allow the boss to bed in, leaving the flat portion of the pattern on the face of the oddside.

Fig. 4 shows a method whereby patterns having unlevel surfaces present no difficulties. The flat sand oddside is used, but the patterns are bedded in, a set-square being used to square them to the joint, two ways of doing this being shown.

Fig. 5 shows how a pattern of irregular surface but with one portion flat may be set on the oddside. Sand is cut away to allow the foot to bed in, and a raising piece of suitable thickness placed under the other end of the pattern.

Some patterns met with will be of such a design that they cannot be set with a square, but to men used to the work they do not often present much difficulty. They will devise some method of setting, such as by using a spirit-level or calipers, often in many instances by simply looking down over the pattern and judging their correctness with the eye, and it is surprising what accuracy some individuals can obtain in this direction.

Where possible the patterns may be mounted on bars as shown in Fig. 6, this making them easier to set on the oddside, and also forming a continuous core-print, using one length of core to two or more castings.

The moulds on to which the matches are to be run should be rammed very hard, and all parts made secure, so that in running projecting portions of sand will not be washed away with the flow of the plaster. Red sand milled very fine is about the best facing to use, as it gives a firm solid joint face, with good impressions of the patterns, and strong enough to withstand the pouring of the plaster on to it.

After setting, the drag is rammed up, care being taken not to disturb the patterns, and the mould turned over. Jointing is the next operation, and calls for extreme care. The parting line of each pattern must be correct, so that when on the plaster there are no portions with undercut, and judgment must be used in order to obtain the best form of joint for successful working. When this is finished and covered with a parting material, a small conical piece of wood or iron is generally placed just where the down-runner will meet the in-runners of gates.

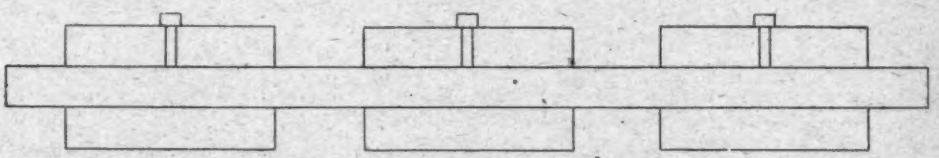


Fig. 6.

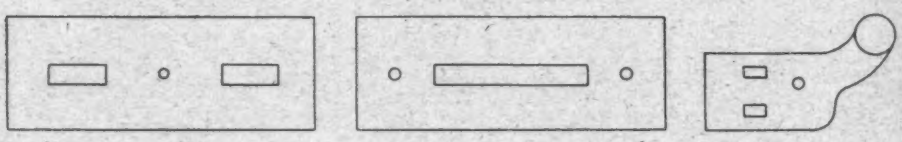


Fig. 7.

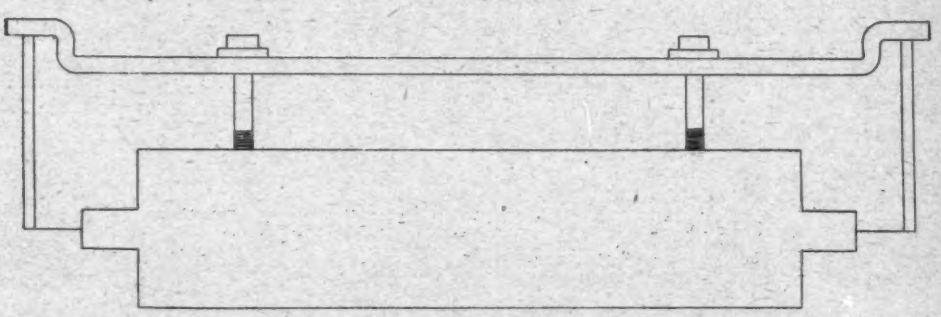


Fig. 8.

The cope is now placed in position, rammed up, taken off, and any damaged portion made good. The small conical piece is taken out and replaced with another similar one but rather longer, which enables it to be secured by the plaster; this piece is introduced to protect the face of the match from being damaged by the tube when moulds are being made. It may be said here that loosening the patterns with a bar to secure a good lift should only be done if absolutely necessary, as by so doing the impression on the cope is liable to get slightly larger than it should be.

After making good the cope the parting material is carefully brushed away with a fine brush, and the

gates cut as in ordinary moulding, but the patterns are not withdrawn from the sand. Plumbago is dusted over the faces of the two parts, and sleeked over very carefully, so as not to destroy the shape or form, as it is essential that the joints should be correct if perfect castings are to be made.

The patterns are at this part of the operation patterns no damage is done to the plaster, and also to prevent the patterns from rusting. The set-screws are used to secure the patterns to the match, their number and positions being determined by the size, weight and design of the pattern. Small patterns without a core in the centre will only require one, with a core in the centre two or more

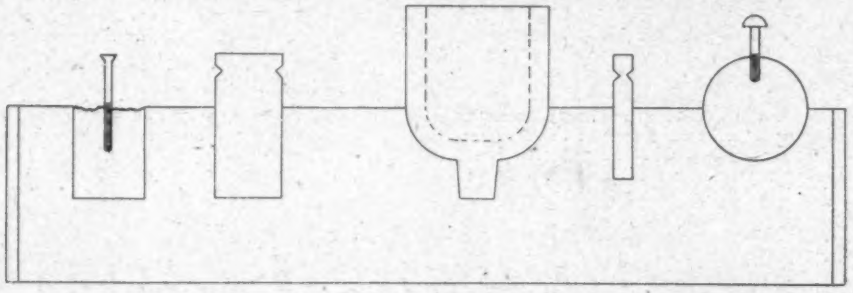


FIG. 9.

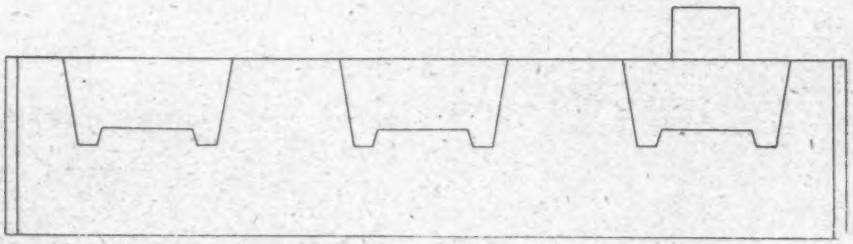


FIG. 10.

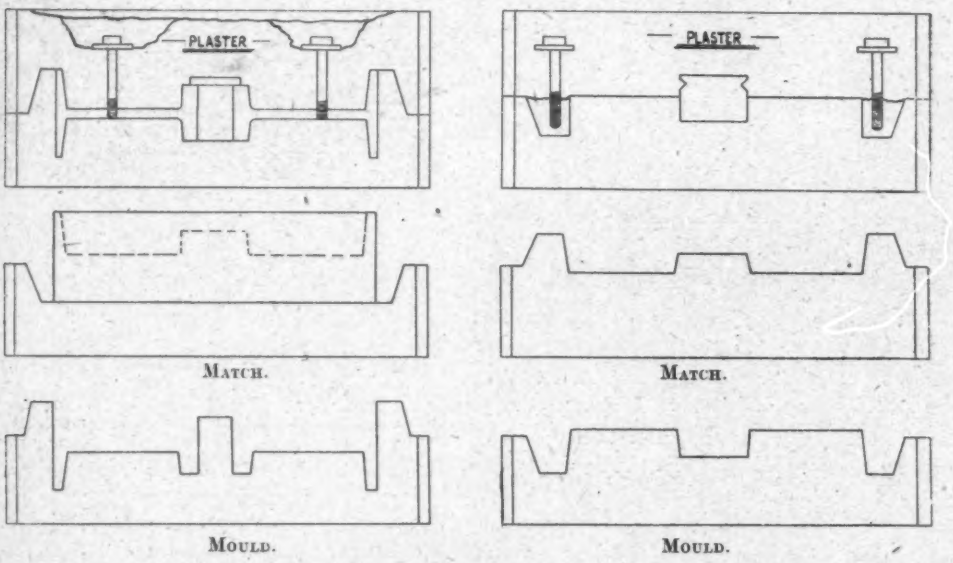


FIG. 11.

given a coat of oil or grease, any cores covered with pieces of tin or thin sheet-iron, and set-screws with washers placed under the head screwed into the patterns, which previous to using have been drilled and tapped for them. The greasing can be omitted if the patterns have been well varnished; it is only done so that if it is necessary to remove any of the will have to be used, and wherever possible the screws should carry the pattern on the balance (Fig. 7). Heavier patterns follow the same rule, but more set screws are used to carry the weight. For very heavy patterns supporting bars are placed across the flask in which the plaster is run, these bars having holes to take the set screws, but it is

only done if absolutely necessary, as weight is added to the match (Fig. 8).

For the match from which the cope has to be rammed no supports are used, but where they are liable to be damaged by the rammer, or where plaster portions would be weak, protecting pieces are placed. These can be made from the pattern and placed in the mould before running, or they can be formed by running white metal into these portions and running the plaster over them (Fig. 9).

The flasks to carry the matches are now placed in position, and for safety a bolt is placed across

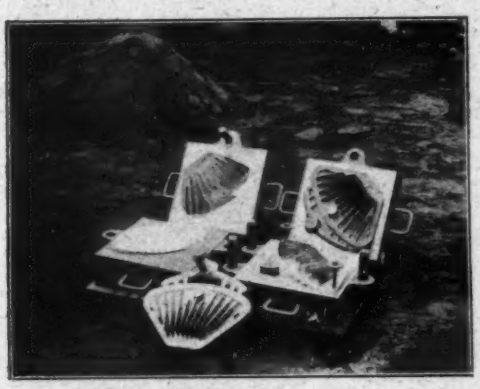


Fig. 12.

them to be tightened up after the plaster has set, so providing a means of securing the block of plaster.

After running and when the plaster has thoroughly set, the matches are removed, and the sand washed off them with cold water, then by using a brush the plumbago is cleaned off also; this should be done before the plaster has gone cold, otherwise the plumbago is very hard to get rid of, especially where the plaster has dropped direct on to the mould.

Each set screw is now tightened with a screw-key, the washer preventing the head of the screw

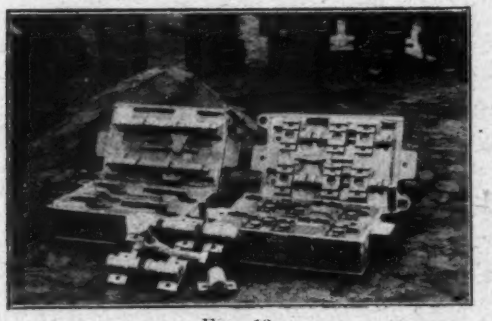


Fig. 13.

from sinking into the plaster, and the cross-bolt also is screwed up if necessary. After the plaster has gone cold the joint faces are trimmed up and given two or three coats of shellac varnish. If a good suitable plaster has been used they should be ready for moulding from as soon as the varnish is dry.

In moulding from the matches the same practice is followed as in plate moulding, but with the exception that the drags are all rammed up first, cored, etc., and then covered with copes, unless they are worked double-handed, in which case one person will make the drags and the other cover them with copes.

It is possible to make matches that will make a number of castings even if only one pattern is furnished. This is done by transplanting the pattern in the mould, the whole afterwards being run with plaster. This, however, is applicable only where there is no danger of any damage taking place due to the patterns not being of sufficient strength if run in plaster (Fig. 10). Only as a last resource should wooden patterns be mounted; the damp plaster coming in contact with them will often cause the troubles which wooden patterns are accustomed to giving when they have been in contact with water. If they have to be used they must be thoroughly greased or varnished so as to be affected as little as possible.

Fig. 11 gives the sections during the stages of making, and of the finished articles from which the moulds are rammed. Fig. 12 gives a view of a finished mould, with pattern and protecting piece in position, also conical piece and set screws. The two parts at the back are finished matches carrying a similar pattern, a casting from which is shown.

Fig. 13 shows the matches and mould for six

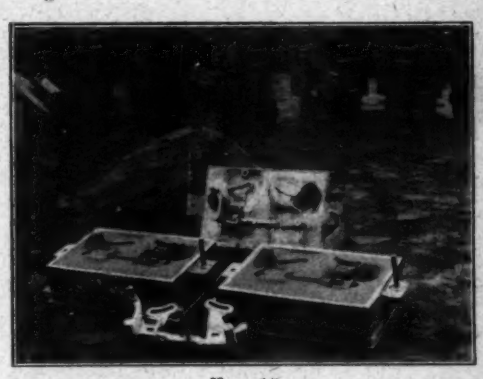


Fig. 15.

similar castings, the patterns for which are mounted on bars. This is a good illustration of what may be done with plaster matches. One can imagine how many would be made by a skilled man in a day with loose patterns, and then consider that the price paid for these works out at 4d. per dozen, and is considered a tit-bit by the men who work the matches. It is also an example where this method shows to advantage in respect to plates, as it is practically impossible to mount this pattern owing to the form of the joint.

Matches can be made whereby double the quantity of castings can be obtained from one set of patterns, using only one match from which to ram both drag and cope. For this flasks are prepared with only two pins, one in each part, also one pin-hole, these being set on two opposite sides of the flask; thus when the mould is complete the parts can only be closed the right way (Fig. 14). This is the arrangement which makes it possible to produce matches from which both parts can be rammed, and the method of making is as follows:—

If it is desired to make a match for a casting or castings, in which the opposite joints would have to cross a centre line parallel with the pins, the patterns are rammed up accordingly—that is,

they are all placed on one side of the centre line, the other half of the flask being rammed with sand but containing no patterns.

The same procedure is adopted as before described for setting, ramming and finishing the mould ready for the plaster, but the flask used for the match has an iron or wooden bar which divides it into two portions corresponding with the mould. This is placed on one of the parts, and the portion covering the patterns run with plaster. Subsequently it is removed, placed in position on the other part of the mould, and the remaining portion run, sand having been previously cut away to allow clearance for the part already filled with plaster. If the dividing bar is loose it can be taken away before running the second portion.

Since mounting, the piece rate is 1s. 3d. per dozen castings. It is used on a machine whereby the patterns are drawn downwards from the mould, but no supports are necessary in the sand. [Two small series of model plaster matches and the moulds to make them upon, and moulds made from them, also castings from the finished article were exhibited and described at this stage.]

As before stated, plaster matches do not supersede pattern plates, but one of their advantages over that method is that any joint that is workable when using loose patterns can be obtained by using matches; to do this on a plate is in some instances impossible; the plates would have to be of such thickness they would be too heavy to work from.

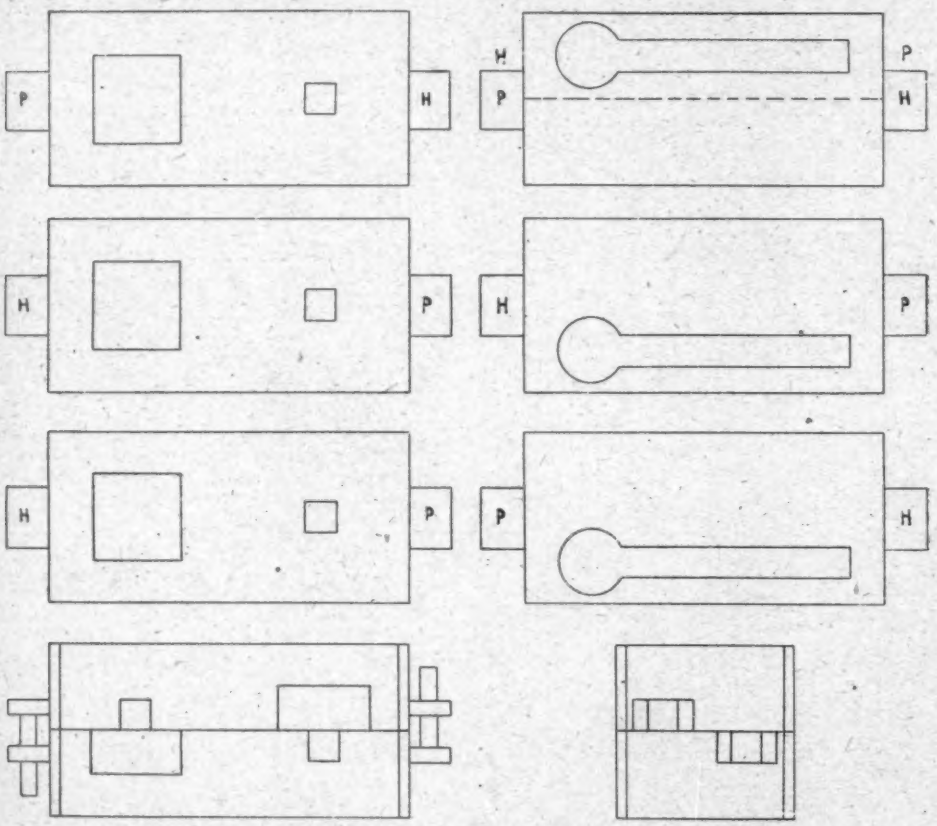


FIG. 14.

If the joints have to cross a line diagonally to the pins, a slight variation is necessary. The flask for the match is divided from pin to pin, and the mould made to suit. In this case after running the first portion the pin must be taken out and placed in the other snug. By these methods the two joint faces are always accurate with each other when the mould is closed; no measuring tools are necessary, nor is any extensive apparatus required, and if the work is carried out in a proper fashion and as described, it is practically impossible to get wrong. Fig. 15 gives a view of a match of this description, also the mould and castings made from it. This is another example of a pattern that cannot be plated. Skilled men used to consider 20 casts per day very good working.

In conclusion, it may be said that the matches will last quite a long time, and hundreds of castings can be made from them before they require re-running, and will prove themselves worthy of notice when the question of cheap production is being considered, as they are easily made at a small cost, and if ordinary care is taken when being used, will soon show a return for the money they have cost.

Discussion.

MR. W. H. SHERBURN said the Paper contained some very useful hints, including a few suggestions which were not in common use at the present time. He noticed that Mr. Hill did not say anything about the mixing of the plaster, whether he followed any special method, or took particular means

to strengthen it. He had seen a good many people mix plaster, but very few who mixed it properly. Plaster was a very tricky thing, having ways of its own, which if observed gave good results, but if not then very bad ones.

Mr. H. Sherburn wished to know the average number of moulds that could be obtained from the matches, also if the weight of them was such as to make the moulding from them an excessively laborious operation, and if this system was recommended for the displacement of pattern-plate moulding.

Mr. Simkiss said that, although he had been very interested in the lecture, there were a few points that he did not agree with entirely. Also, he would like to ask a few questions in regard to the subject. Personally he did not care for the pulley joint; he thought that it was the wrong fashion to make, and would like to know Mr. Hill's reason for the same. He also thought split patterns mounted upon a pattern-plate preferable, or else the use of a sand oddside for the purpose of turning over and working the patterns loose, seeing that they were not required continuously. He would like to know if any trouble was encountered with heavy patterns in the pin and pin-hole system, due to one section carrying the bulk of the pattern in the cope; and would also like to know the weight of a casting as shown in Fig. 13; and also what Mr. Hill meant by the plaster going cold.

Mr. Key remarked that he thought this system, if carried out to a great extent, would hold up a large number of moulding flasks, and if some system could be devised whereby a snap flask could be used to hold the blocks of plaster whilst moulds were being from them, the blocks could be stored without the flask, so that one only would be required for a series.

Mr. Hill replied that he had done a good deal of experimenting with plasters of different qualities, both with admixtures of other materials and by themselves. The best results were obtained by using "seconds" plaster without any additions of other materials. He remarked that anyone who had had any experience of mixing plaster would know that if mixed slow the water would not take up the same amount of dry plaster as would be the case if mixed quickly, and that his practice was to mix up quickly—at the same time thoroughly—until the mixture was in a stiffish condition, when it was poured into the flasks as soon as possible. By using this method he had always obtained satisfactory results. In regard to the number of moulds that could be made from the patterns, it depended to a great extent on the person using them. If reasonable care was taken, enormous quantities of castings could be obtained by their use before re-running, which, after the first instance, was a very simple affair.

The weight, of course, depended upon the size of the flask, but 2 in. of plaster should be quite sufficient for the general run. Here, again, a good deal depended upon the individual who worked from them. The system he used was as follows:—If it was found that, through carelessness, the matches were unduly damaged, he took good care that the next one run was thick enough in section to withstand ill-usage, and it was not very long before the man asked for the lighter matches, and was prepared to use them in the right fashion.

Referring to Mr. Simkiss's remarks, Mr. Hill said that he did not claim any advantage for the pulley joint as shown, and had merely given it as an illustration of the possibilities that could be obtained when dealing with sloping joints. In regard to split patterns, he wished to point out that in the paper it was explained that one of the benefits of this system was that it enabled existing patterns to be used, and was generally used to save the expense that would be required for fresh ones, especially for jobbing orders. If only a very small number of castings was required, then the sand oddside system was the best, and was the one he used in his own practice. No trouble had been encountered with the pin and pin-hole system, owing to the cope carrying the main portion of the pattern, in his experience, though he would not care to make exceptionally heavy or bulky castings in this fashion. The weight of the casting shown in Fig. 13 was about 4 or 5 lbs., and what was meant by the plaster going cold was that, on setting, a certain amount of heat was set up, and the plaster was quite warm for a certain period. He agreed that a good number of flasks were put out of use by this system, but their value was of more account in the long run than would often be the case if they were not stored away, and he thought that was a secondary consideration. The value of an accurate interchangeable system would be great if some effective means could be devised to protect the edges of the blocks.

Mr. Penlington remarked that the title of the Paper did not indicate that it was a question of the best or cheapest method, or the only method of making plaster matches, but rather that Mr. Hill had found his way the most effective for the work he had to do, and he was evidently satisfied with it. Indeed it was questionable whether they could make them in any other way, and that being so there was not very much to discuss. One question might be raised, namely, as to whether his method of making the joints was correct or not. Whether it was the best and cheapest way was another matter, which was not under discussion. A given method might be the best and cheapest in one shop, while in the shop next door it might spell disaster.

Light Alloys for Aircraft.

Mr. F. J. Selby, secretary of the Advisory Committee for Aeronautics, Teddington, writes that the committee has appointed a light alloys sub-committee with a view to the co-ordination of the work which is now being done in connection with the use of light alloys in the construction of aircraft and aircraft engines. The functions of this sub-committee will be to advise Government departments on questions relating to light alloys, to institute research for the development and improvement of such alloys and of the methods of working, and to assist in the removal of difficulties which may arise in practice in their production and use. The sub-committee will be in close touch with the experimental work on light alloys, and hope to be able to give advice and assistance to manufacturers undertaking the production of light alloys, and to founders engaged in the manufacture of engine parts, cylinders, pistons, crank cases, etc. They trust to have the co-operation of firms who have undertaken such work, and will be glad to receive suggestions and to give any help that may be possible in answer to inquiries.

The members of the Committee are:—Mr. Henry Fowler, Superintendent of the Royal Aircraft Factory, chairman; Lieutenant-Commander C. F. Jenkin, R.N.V.R., and Professor F. C. Lea, representing the Air Board; and Captain H. P. Philpot, Mr. A. W. Johns, and Dr. W. Rosenhain, representing respectively the Aeronautical Inspection Department, the Director of Naval Construction, Admiralty, and the National Physical Laboratory; together with the chairman of the Advisory Committee for Aeronautics, *ex officio*.

Titanium in Steel Castings.

In a recent Paper before the American Foundrymen's Association, Mr. W. A. Janssen points out that, notwithstanding all that has been said regarding the harmful effects of phosphorus and sulphur in steel castings, occluded gases and oxides are the real causes of many of the troubles of the steel foundryman. In the elimination of these difficulties, ordinary deoxidisers, such as ferro-manganese and ferro-silicon, have their place, but if the best results are to be achieved a more potent reagent is necessary, and for this purpose ferro-titanium has proved unusually satisfactory. Until a comparatively few years ago titanium was looked upon as one of the rare metals. It is undoubtedly one of the most powerful deoxidisers and denitrogenisers known. Its chief value lies in its positive action in the removal of the occluded oxides, nitrogen and entrapped slags, due to the fusibility of titanic oxide as formed, and its greater stability as compared with iron oxide. Its function is further augmented by the increased fluidity due to the increased temperature, because of the exothermic reaction, thereby permitting freer movements of the oxidised products to slag.

The present-day method of using ferro-titanium is to augment the incompleted cycle with ferro-titanium after the other deoxidisers have been added. These may be added in the ladle, or in the furnace before tapping. After the titanium has been added, it is *imperative* and *essential* that the ladle be held from five to ten minutes before pouring in order to allow time for the completion of the reactions. No fear need be had of the chilling of the metal, inasmuch as the temperature is raised appreciably, due to the exothermic reaction. It is essential that the titanium be not added until after the additions of ferro-silicon and ferro-manganese have been made. On account of the greater affinity of titanium for oxygen, the ferro-silicon and ferro-manganese must be given an opportunity to complete their primary deoxidation, thereby eliminating selective oxidation. It is also essential that the ferro-titanium be added as soon thereafter as possible so that the alloy does not become a part of the slag and there perform its deoxidation.

Ferro-titanium has its application as a deoxidiser and cleanser in the crucible, converter, open-hearth and electric furnace processes of steel manufacture, as well as in the cast-iron and malleable-iron industries. If ferro-titanium be used in the crucible process, it may be added as a part of the charge, being placed well down toward the bottom of the pot, or added after the manganese addition has been made. Because of its intensified affinity for occluded gases and cleansing action on inclusions, its use extends to the metallurgical processes for the more common non-ferrous alloys and also to the rare metals.

Titanium in combining with oxygen to form titanium-oxide, with a heat of formation of 215,000 calories, acts as a flux for silicates and other slags, which normally would remain in the slag, rendering them sufficiently fluid to rise through the metal and pass into the slag. Titanium at about 800 deg. C. combines with nitrogen to form the stable titanium-nitride which usually finds its way to the slag. Microscopic examination, however, sometimes reveals the existence of occluded tiny, hard, pink crystals of titanium-nitride, which, however, are less harmful in effect than the occluded nitrogen. With all these beneficent effects, its use beyond a certain amount is of no avail and in a measure harmful.

Titanium, singularly, does not form alloy steels as do the other deoxidisers, such as silicon, manganese and vanadium. Many analyses of titanium-treated steels do not reveal a titanium content higher than 0.025 per cent. With the use of alloys containing more than 10 to 15 per cent. titanium, the results are not as effective, owing to the slower rate of solution.

The amount of ferro-titanium used depends in a measure on the kind of steel to be treated. In rail steel, an addition of 13 lbs. of the 15 per cent. alloy per net ton (2,000 lbs.), representing a metallic titanium addition of 0.10 per cent., is satisfactory. In the use of titanium for steel castings the addition of 1½ to 2 lbs. per ton of metal charged, in addition to the usual ferro-silicon and ferro-manganese additions, is usually sufficient to deoxidise the steel. The amount of ferro-titanium added, however, should be dependent on the quantity of impurities which are to be removed and the process of manufacture.

In the low-carbon or soft steels the presence of blow-holes, occluded gases and slag inclusions is greatly aggravated due to the metal being longer subjected to the oxidising action of the flame or blast, or because of its being necessary to increase the temperature of the metal for successful and economic teeming. Soft steels, because of this low carbon content, cool more rapidly after having reached a point of initial solidification, whereby the occluded gases are not afforded sufficient time to escape before the metal has reached its plastic state. Titanium, properly apportioned in conjunction with proper treatment, will cleanse and purify the metal. With the use of titanium in the higher-carbon steels, it has been found that these steels are softer and less brittle than steels of the same carbon in which titanium has not been employed, due in all probability to the more uniform distribution of the ferrite network.

In alloy steels, where special alloys such as nickel, chromium and manganese are added because of a special function, the quality and properties of the metal are improved by the further addition of titanium for the elimination of the oxides of nickel and chromium, both of which contribute to the brittleness of steel. The manufacture of manganese steel is greatly benefited by the proper addition of titanium. With the use of this alloy, the manganese is disseminated uniformly, resulting, with proper heat treatment, in a tough, homogeneous product.

With the elimination of the occluded oxides and slags, steel, because of its increased density and homogeneity, has improved static and dynamic properties. A comparative test of 20 untreated and treated heats showed an increase in the ultimate strength of approximately 15 per cent. with no reduction in elasticity and contraction. A remarkable endurance test was conducted by Enrique Touceda on untreated and titanium-treated steels of practically the same chemical composition. The test was conducted in a Wright-Souther machine at a fibre stress of 38,872 lbs. The untreated steel withstood 2,676,000 revolutions at this pressure, whereas the titanium-treated steel withstood 18,274,900 revolutions at pressures varying from 38,872 up to 45,939 lbs. fibre stress.

Many tests made on rails and machine parts indicate the ability of titanium-treated rails to withstand shocks and abrasion, the life of gears and rails being about 50 per cent. greater than those made of untreated steels.

The Effect of Silicon in Cast Iron.

By R. T. Rolfe, F.I.C., M.Inst.Met.

The Paper on "Cast Iron" by Mr. Adamson, published in the last issue, although of great interest, will be read with surprise by most metallurgists, and is in many respects open to criticism. His contention that of recent years the metallurgical world has been divided into two schools, of analytical chemistry and physical chemistry, each radically opposed to the other, is a most extraordinary one.

The point of view of the average metallurgist is that cast iron is a very complex mixture of different metalloids, that the relative proportions of silicon, sulphur and the other constituent elements that are present must exercise a considerable influence upon the properties of the material; but also that the various physical or chemical changes that occur between smelting the metal in the blast furnace and machining the finished casting must also exercise a considerable effect. Many of the physical changes may, of course, produce chemical ones. It is, however, unprofitable to estimate the relative importance of the effects of chemical and physical changes taking place in iron upon its mechanical qualities. Due regard must be paid to both. They are so inter-connected that they can only be studied together, and any attempt to treat the matter from the standpoint either of analytical chemistry or of physical chemistry alone can only lead to disaster.

It is quite possible that there are analytical chemists who consider that a complete analysis of a sample of cast iron will tell them all about its physical and mechanical properties, but they must be rare creatures. The truth is that two different irons with very unlike mechanical properties may have the same or almost the same composition. Analysis is of distinct value, but the results obtained from analysis must be co-ordinated with all the other data before any conclusions can be drawn. Mr. Adamson, in his endeavour to discredit what he describes as the school of analytical chemistry, has flown to the opposite extreme, and fails to attach sufficient importance to composition.

Let us examine one of his assertions in detail, the statement that silicon content in cast iron does not *control* combined carbon and its ratio to graphite. It is obvious that the correctness or falsity of this assertion depends entirely upon the interpretation of the word "control." If by controlling is meant that over a number of different irons variation in the silicon content will automatically produce a corresponding variation in the relation of combined carbon to graphite, *irrespective of all other variations in the conditions*, then silicon will certainly not control the distribution of carbon.

He admits, however, as "an undoubted fact that, taking a given iron, under exactly the same condition of melting, pouring and cooling, the higher the silicon the softer the iron within limits," thereby admitting that under these conditions the silicon *does* produce a corresponding variation in the proportion of graphite, or, in other words, *controls* it.

The only logical deduction from this is that the increase of silicon in cast iron is a factor which *tends* to convert combined carbon into graphite, but the effect of which, as he shows elsewhere, and as has been previously pointed out by other authorities, may be overruled by other factors, such as size of casting, temperature of casting, rate of cooling down after casting, etc.

Mr. Adamson lays great stress upon the fact that Professor Turner's original classic researches upon the effect of silicon were on irons containing some 2 per cent. only of total carbon, and that such a total carbon does not occur in modern commercial pig-irons. He, however, completely ignores the fact that similar researches have since been carried out by other experimenters on commercial pig-irons, with precisely the same results. That silicon does exercise this effect has been demonstrated by W. H. Hatfield in a Carnegie Research memoir (Journal of the Iron and Steel Institute, 1906), from which the following results may be quoted:—

Hatfield's Series A (Test-bars 1 in. by ¾ in. in section, all cast at normal heat).

Test No.	Analysis						Maximum stress tons per sq. in.	Fracture.
	Combined Carbon. %	Graphite %	Si. %	Mn. %	S. %	P. %		
7	2.9	trace	0.28	Not exceeding 0.20 per cent.	Not exceeding 0.05 per cent.	Not exceeding 0.05 per cent.	18.0	white
8	2.9	,,	0.53				22.8	,,
9	2.9	,,	0 63				14.5	,,
10	2.9	,,	0.66				13.4	,,
11	2.9	,,	0.88				17.4	,,
12	2.9	,,	0.99				18 1	,,
13	3.0	,,	1.10				16.0	,,
14	2.7	0.28	1.43				11.22	trace mottled
15	2.3	0 65	1.68				11.40	mottled
16	0.6	2.47	1.72				12 70	grey
17	0.55	2.6	1.80				10.70	,,
18	0.55	2.68	1.96				14.9	,,
19	0.5	2.75	2.07				8.5	,,
20	0.5	2.75	2.19				15.6	,,
21	0.49	2.8	2.36				9.8	,,
22	0.48	2.85	2.50				9.06	,,

Hatfield's Series B (cast hotter than Series A).

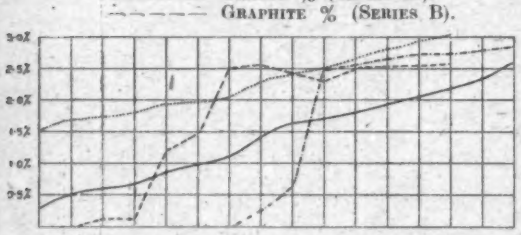
Test No	Analysis.						Maximum stress tons per sq. in.	Fracture.
	Combined Carbon %	Graphite %	Si. %	Mn. %	S. %	P. %		
23	3.00	trace	1.51	Not exceeding 0.20 per cent.	Not exceeding 0.05 per cent.	Not exceeding 0.05 per cent.	11.6	white
24	3.00	,,	1.71				9.4	,,
25	2.90	0.10	1.73				12.0	slightly mottled
26	2.91	0.11	1.80				11.0	,, ,,
27	1.78	1.20	1.95				19.6	mottled
28	1.50	1.47	1.97				12.4	,,
29	0.62	2.50	2.05				15.0	grey
31	0.55	2.55	2.31				8.4	,,
32	0.78	2.40	2.41				14.4	,,
33	0.75	2.30	2.50				13.1	,,
34	0.49	2.50	2.67				10.6	,,
35	0.51	2.55	2.82				8.19	,,
36	0.52	2.55	2.94				8.21	,,
37	0.47	2.60	3.05				8.66	,,

The chief characteristic of the two series, as shown by Hatfield, is the rapid change from combined carbon to graphite, which when the casting temperature is higher, takes place with a higher

silicon content. The effect of the increase in the silicon is plotted graphically in the accompanying diagram. Further researches demonstrating the same effect of silicon have been made by Longmuir and by Haigh and Turner.

One of Mr. Adamson's methods of demonstrating that the silicon does not control the proportion of combined carbon is to take the analysis figures of twenty-one presumably different irons, cast under conditions which are wrapped in mystery, and which may, for all that is stated to the contrary, have been produced under widely varying conditions in many different furnaces. He is unable from these figures to trace any relation between the proportionate quantities of silicon and graphite. There is, of course, no reason why he should. The effect of silicon is not absolute but conditional.

Throughout his Paper Mr. Adamson lays stress upon the importance of "properties produced in the course of manufacture and treatment. . . . Only after that are the physical or mechanical properties of iron modified by chemical composition." This is putting the cart before the horse. Cast iron is composed of certain constituents, which if present in abnormal proportions, may impart totally



different properties to it. Thus, for example, excess of silicon may produce such an alloy as "Tantiron," excess of combined iron, white iron, and so on. In cases where no element is present to an abnormal degree, however, variations in the proportions of those different constituents must still affect the properties of the mixture. Furthermore, however, as Mr. Adamson suggests, great changes may be produced by different treatments.

The author badly misuses the term "chemical analysis." To talk of "the influence of chemical analysis on the physical properties of cast iron" means nothing. Chemical analysis has no more effect on the properties of cast iron than it has on the rotation of the earth on its axis. It is the *composition* that he means, and the composition of an iron is ascertained by chemical analysis.

Again, in the interests of clarity of thought, why does Mr. Adamson say "from the freaks we learn the truth." The old saw has it that it is the exception that proves the rule, because it is an exception, not that you must believe it. In the case in question Mr. Adamson is, of course, quite right in saying that silicon content does not control the percentage of total carbon, but why use such a deplorably weak argument as the above. He is again right in laying stress upon the effect on cast iron of varying temperatures obtaining in the blast furnace and of variation in the time of remaining there, but why make use of such a phrase as "temperature and time," which has no meaning as it stands, and then suggest that it is sometimes *translated* as "mass," meaning slow-cooling. Mass refers to size only, not to temperature or time. It is all extremely loose and vague. The fact is that temperature and time are two factors that may operate in the case of iron remaining in the blast furnace to produce various changes therein. They also apply quite well to a large body of metal being melted in the cupola, or cooling down after solidification, etc. It is thus quite arbitrary on Mr. Adamson's part to say that the term "temperature and time" is not intended to apply to "mass," but to the conditions existing inside the blast furnace. One can see what he is driving at, but it is an extremely bad way of putting it. The last sentence on p. 75 is most mysterious.

Mr. Adamson emphasises quite correctly the effect on white iron of slow cooling, that if one has a large enough body of molten metal, which will naturally cool very slowly, the effect of the slow-cooling (even if no silicon at all were present) may be to convert largely the combined carbon into graphite. The same effect will take place in the presence of very varying proportions of silicon. The lengthy cooling will overrule any other factor.

This does not mean that varying silicon is not a factor to be reckoned with, but only that it must be given its due importance. This may be sometimes nil, and sometimes very great. It seems unnecessary to labour the point further.

COBALT.—A series of researches on cobalt and its alloys was undertaken for the Mines Branch of the Canadian Dominion Department of Mines by H. T. Kalmus at Queen's University, Kingston, Ontario. The investigations include a study of cobalt alloys of extreme hardness, and of those with non-corrosive properties, and the magnetic properties of cobalt and ferro-cobalt. As a steel-alloying element, cobalt has been employed with notable success in high-speed steels. Steels containing about 4 per cent. of cobalt, in addition to tungsten and chromium, make high-speed tools which retain their edge well at or near a red heat, and will cut or turn manganese and nickel-chromium steels successfully. A German steel, somewhat misleadingly called "iridium steel," contains approximately 4.25 per cent. cobalt, 16.00 tungsten, 3.55 chromium, 0.67 vanadium, 0.80 molybdenum, and 0.60 per cent. carbon. Ferro-cobalt, containing about 70 per cent. of cobalt, is the usual form in which the cobalt is added to steel. An alloy of cobalt and iron, approximating to Fe_3Co, has been found to possess a magnetic permeability in strong magnetic fields which is about 10 per cent. higher than that of the best Swedish soft iron. Small percentages of cobalt added to pure iron give alloys which resist corrosion and are suitable for roofing. The original stellite is an alloy, containing about 75 per cent. of cobalt and 25 per cent. of chromium. By the addition of molybdenum and tungsten the stellite alloys are made very hard. In some experiments with the chromium maintained at 15 per cent., it was found that the alloy gradually increased in hardness with the percentage of tungsten. When the quantity of tungsten is 5 per cent., the alloy is distinctly harder, particularly when forged under the hammer. With 10 per cent. of tungsten the metal still forges readily, and is suitable both for cold chisels and for wood-working tools with a fine cutting edge. When the tungsten rises to 15 per cent. the metal can still be forged, but great care is necessary to avoid checking. This alloy is considerably harder than that containing 10 per cent. tungsten, and is excellent for cold chisels. When the tungsten rises to 20 per cent. the alloy is still harder and can be forged to a small extent. With 25 per cent. of tungsten a very hard alloy is formed, which cannot be forged, but casts readily into bars which can be ground to a suitable form for lathe tools.

Sands and Cores.

At a meeting of the London Branch of the British Foundrymen's Association, held on Friday, February 16, Mr. A. R. Bartlett (President of the Branch) in the chair, a discussion on "Sands and Cores" was opened by the Hon. Secretary, who read a brief paper on "The Properties of Sands for Foundry Work."

The Chairman then followed with a Paper, illustrated by a comprehensive selection of cores and sands. The Paper was as follows:—

Sands.

Sands for moulding or core making are one of the absolutely necessary tools that the foundryman must use, yet we find no settled opinion as to which is the best procurable. The sand we are in the habit of using is the one we rely on and the only one we have any confidence in. Each district has some sand easily procurable, and this naturally forms the base of all the sand mixtures used in that district. The cost of getting any other sand is prohibitive owing to keen competition. Metals, coke and all other commodities used in the foundry have to be brought in, but they are to be procured in any grade or quality desired; but with sand it is invariably something that can be got for very little cost that has to suffice, quite irrespective of the fact that there may be something much better and if worked properly would be really more economical.

Mixtures of sand of just the right qualities and quantities would greatly assist to eliminate the faults caused by using the wrong mixture. Among others, some of the faults in castings caused by indifferent mixtures are blow-holes, rough surfaces, swells, buckle scabs, burnt-on sand, sand that runs before the metal and causes thin scabs that when chipped off give a most unsightly appearance to the casting, while the same sand floating to top surfaces, if the casting is to be machined, spoils the appearance and ruins the casting if it gets into any working part. Even with all the faults mentioned, nearly any sand after careful experiments can be made into useful mixtures for many moulding and core-making purposes.

Any and every sand as dug from the pits needs some treatment before it is suitable for moulding purposes. We all know the absolute need of some form of artificial opening of the sand to help the passage of gases or air or steam, either coal dust, coke breeze, sharp sand, dung, sawdust, or other material. Also we fully appreciate the advantage of thoroughly mixing, so as to distribute the opening compound evenly through the mixture. This mixing, if done efficiently, breaks up the clay content, which, though necessary as a bond, is fatal if in uneven quantities, clay itself being a great enemy to the foundryman if not properly controlled. Uneven dryness or patchy mixtures are very bad in practice, for then what is good moulding practice on one part of the mould is fatal on another.

In buying moulding sand we get no specification whatever, the merchant simply stating that he can supply sands that are used in this or that district and that they are good moulding sands. This is generally satisfactory where the individual has got used to his sand and knows how to use it, but when it reaches the hands of the men who do not know it, it is pronounced bad.

The greater the clay content of sand the more silica sand must be used to make it an effective moulding sand. There is a great difference of opinion as to the correct amount of silica and clay that should be contained in a correct moulding sand, but the majority of opinions hover round 80 per cent. silica and 20 per cent. clay. This, of course, will need to be varied according to the class of castings to be made, whether light or heavy, the light needing a greater percentage of silica and the heavy casting a smaller percentage.

All sands have qualities that are described in different terms by different individuals. Some will claim that a sand is fine and therefore a good moulding sand, where another will say that it is too close. Again, some will look for porosity in the sand and capacity to take water without causing blows and scabs. Another will look for strength, or what is termed "bond," and if the sand binds well together when squeezed in the hand, it is pronounced a good sand. All these opinions are formed through using one sand more than another, and making that the standard by which all sands are judged.

By fineness I think we should mean the smallness of the grains or particles, a fine sand is not usually a very porous sand; that is, one in which the air finds an easy passage. In a porous sand the grains must of necessity be larger than in a fine sand. An example of fine sand is a clay bonded sand of the type usually found in the Thames Valley, as at Erith and Grays. A moulding sand of great porosity is that represented by Mansfield, Runcorn, Birmingham, etc., and is commonly known as rock sand. No doubt the grains in what is termed a rock sand are much larger than in the fine sand, and of necessity cannot be packed or rammed so close; therefore the air passage is much more free.

In speaking of bond we must always remember that the amount of water in the sand must be taken into consideration, for no dry sand has any bond whatever. From experience we know that a fairly dry mixture when milled feels much more moist when it comes from the mill than what it did before milling. This condition is brought about by the even crushing and distribution of the clay contents, which hold the most moisture.

Cores.

Undoubtedly core-making has been carried on successfully from the time metal founding commenced. The methods employed have to a very great extent all been similar. Sands and core irons have always been a necessity and vents have always had to be placed in the desired position to ensure the escape of gases when the moulds have been poured.

Where a few years ago the base of most core sand or loam mixtures was yellow sand, or in some parts of the country a red sand or other local sand, nowadays we have, since the introduction of binders, a sand which is more universally used, viz., sea sand or river sands. The chief reason for its introduction must be the ease with which it can be fettled, the free passage of air through it, and the reduction of cost in the produced casting through the various advantages gained by its use.

Of course, the adoption of binders with sea sand does not apply for all cores, as where heavy castings are made a much stronger compound is

required to withstand the pressure of the metal. In these cases we still have to rely on the old-time mixtures having strong loam for their base, and of necessity sturdy core irons to stiffen and keep the cores in the desired shape. But for light castings, and castings having intricate internal shapes which would make the removal of the cores a difficult task, core binders help us to greatly eliminate irons and their nature makes the fettling an easy matter. We all know how readily a properly arranged sharp sand mixture runs from the casting with practically only a few taps from a hammer or a few turns in a rumbler or tumbling barrel. The use of the sand blast has only been made possible since the introduction of sharp sands and binders for cores.

Binders are now made from various materials. There are oils of various classes, water-soluble binders, such as molasses, glue, glutrin, etc., paste binders, such as starch and flours of several sorts, also gum, tar, pitch and resin. Clay is also used by many as a binder. All binders are simply used as a means of holding the grains of sand together, so as to enable the cores to be handled, also to help them withstand the pressure of the metal. Consideration must be given to the relative advantages of each binder, some of which are the added strength given to the sand mixture, both in the green state and after it has been dried, the skin of the core and the condition of the surface of the casting when the core is removed, the resistance offered to moistures and the core's power to keep firm after being placed in the mould during the period of waiting for the pouring of the metal, the ease with which the core can be removed from the casting, the passage of air through the core, the cost of drying, the unpleasant fumes from some binders and the possibility of their elimination, the possibility of handling the cores, or the necessity of special core boxes or plates to make the mixtures useful. Also must be considered whether one can make more cores per hour with the aid of binders and thus reduce costs, and whether a binder will reduce the drying costs. Practically all these matters resolve themselves into a question of cost.

All cores made with the addition of any binder, need careful watching during drying, for if the core is taken out of the stove before being dry enough it has not the desired strength, and if left too long the strength is lost, or, as we generally term it, the core is burnt and useless. Some binders during heating ferment, and thus if used in excessive quantities tend to distort the core and render it useless. Also oils, if used excessively, make the surface too hard, and thus cause blowing and pitting on top surfaces of the casting. All sharp sand cores to which a binder has been added, when dried have a hard exterior skin and a soft interior structure; this is, of course, plainly perceptible to all moulders, as a distinct aid to the free passage of air and gases.

By sharp sand is meant sand that has no natural bond, so that it is absolutely necessary to have a binder of some description to hold the sand together. Oil is undoubtedly the most useful and easily mixed binder. It gives the core a good skin and the soft interior. But it has its disadvantages in the fact that it is dirty to use and gives off a very unpleasan smell, both during drying in the stove and after the metal has come in contact with it. Also it is higher in cost than most other binders, and during the present crisis it is very difficult to get regular supplies. If used in excessive proportions the core during drying will flatten and thus an inefficient core be the result. The same applies to soluble water binders. Therefore tests with the sand to be used will give the ideal quantity of binder to use and the desired strength.

All sugar binders, such as molasses, etc., have the tendency to ferment and boil when in contact wtih heat; therefore, the mixture must contain only sufficient of these to be effective, as an excess will cause the core to burst or crack and thus become distorted and useless.

Sour beer is oftimes used as a binder, the sugar content being the real binder, but seeing that it is in a small proportion to the whole, it has not the tendency to ferment as with molasses. Glutrin and glue do not ferment in the same degree, therefore for somes sands, particularly those containing a small proportion of clay, they are very useful binders.

All flour or starch binders have no tendency of this nature, but they have not the binding strength of the previously-mentioned binders. Tar, resin and pitch are useful, but being highly inflammable they give off unpleasant fumes during drying and when in contact with metal, and are not very good for castings that have to be machined, as the top surfaces of the casting when tooled expose the holes formed by the gases given off from the binder during contact with the molten metal.

All binders to be thoroughly effective, must be well mixed with the sand, so that the binder is distributed evenly throughout the whole. The best way to do this is to have the sand dry, then put the binder with it and thoroughly mix, adding water to temper after and thoroughly mix again. With sharp sand and the correct amount of binder no ramming is required, and a correctly arranged mixture will make cores that will stand for a very long period, and still be good useful cores; whereas the ordinary clay bonded sands when made into cores get rotten after a very short time and become useless. Here again oil has the advantage over all other binders, in the fact that cores made with it do not absorb moisture, and, therefore, will not require placing in the stove a second time before using.

With all the binders mentioned except clay the cores after contact with the metal leave the castings very freely, and with brass or bronze castings it is very often the custom to place them in water while hot and thus blow the cores out. This method is, of course, not practical with iron castings, owing to the hardening effect upon the castings coming into contact with water while hot. All clay-bonded cores get harder on contact with the metal, and are, therefore, much harder after use than when placed in the moulds, necessitating very often a deal of trouble in fettling.

The fumes given off by oil and other inflammable binders, and the unpleasant smell which clings to the workman using oil, cause a great deal of prejudice against its use by the workmen. This being the case it behoves us to use the less offensive binders wherever practicable, for from the contented man we get a greater production, and our health must be better for the purer atmosphere. Of course, a large amount of unpleasantness can be avoided at casting time if the gases from vents are lighted.

Unless special tackle is made for oil-sand cores that have round surfaces, it is necessary to make the cores in halves or on such lines that there is a

flat surface, so that the core can be placed on a flat plate. Otherwise, in putting sand round the core and then placing the plate on and turning the core out, one is liable to get a distorted core, that will be of no use. For instance, in making cores for bombs it is the custom in most foundries doing this class of work to have a large number of half core-boxes made in iron; the bottom half core is made in these and the top half in another core-box that fits it. The bottom half core being made, the top half is then put on it, and the top box taken off. Seeing that the oil has an affinity for itself, the half cores when dried will be found to have stuck together, and can then be removed from the bottom core-box.

Methods of this description are only justifiable where there are large quantities of the one job to make. Oil-sand cores take longer to dry than do cores with most other binders, and if not thoroughly dry are sure to fall to pieces when handled. Other binders have not this failing, seeing that the water used with them does not come to the outside of the core during drying like oil does.

With oil we do not get the sand sticking to core-boxes, but with all other binders this tendency is pronounced, and it is, therefore, necessary to use some form of parting, such as paraffin or burnt sand, otherwise parting sand.

It must not be thought that oil-sand means oil and sand only. This is not so, a large amount of water is used in an oil-sand mixture. But with this mixture, as with all others, my experience is that it is best to use dry sand, then add the oil or other binder, thoroughly mix and then add the water to temper. I might mention that an oil-sand mixture may vary according to the size of core, the larger the core the less oil required. The same applies to all other binders, the reason being that in the larger volume the core has a greater stability in itself. We use mixtures varying from 1 part oil and 35 parts sand, to 1 part oil to 50 parts sand, and water to temper, usually from about 5 to 9 parts water according to amount of oil used, the more oil the less water. Large quantities of oil-sand should not be mixed, as the oil has a tendency to run to the bottom of the heap and be lost. It should be mixed in small quantities, just as much as each individual core maker will use between meal-times. This tendency of the oil running to the bottom, of course, takes place in the core, and causes it to stick to the core plate when drying. To avoid this we place paper between the core and plate as a parting. The paper can be easily procured, as all envelopes and other useless wrapping that comes through the post and around goods can be used for this purpose. This is our method, and naturally costs us nothing, our good friends who send advertising literature helping us unconsciously.

Mr. Bartlett then described the manner in which the cores which he exhibited had been made. They were a series of cores made on a rotary core machine, and owing to difficulties in getting the usual binders a number of samples of other binders were secured and experiments made. The cores in question were made some time ago, and not for the purpose of the meeting. The aim was to secure cores the full length of the guide plate, viz., 2 ft. in length. Generally speaking, he did not use oil owing to the expense, but when it was impossible to get other materials then he had resort to oil and sand mixtures. Describing the exhibits seriatim, the first core was made from a mixture of one part of liquid binder made by Corebind, Limited, and ten parts of water. Five parts of this was added to fourteen parts sea sand and two parts flour, but it made a mixture apparently too strong, the core being too hard. More flour appeared to be necessary, or less water and more binder, the water having the tendency to sink to the bottom and carry the core with it. In giving the names of the binders used, in deference to the wishes of the members, Mr. Bartlett explained that he had no interest in any particular one, his object being to make every type of binder work with the rotary core machine, so that if he could not get one he would be able to work with another.

The next core was made of the same mixture as before, but with a different quantity of flour. There were three parts of the mixture instead of five, fourteen parts of sea sand, but only one part of flour. That gave a weak core that would hardly stand handling. It came out 2 ft. in length, but was very rotten. It appeared to be weak as regards binder, and although it went through the machine successfully the solution needed strengthening.

A mixture of one part of the same liquid binder and eight parts of water was then made up. Two parts of this, with fourteen parts of sea sand and one part flour, gave a core which would not hold together and quickly developed cracks.

Two parts of a mixture of one part of liquid binder and six parts water, together with fourteen parts sea sand and one part flour, gave a core of no use whatever for practical purposes. It was not rigid enough to carry through the die and along the guide plate; it was not strong enough to push itself along the conveyor.

Two parts of a mixture and one part liquid binder and six parts water, together with fourteen parts sea sand and one part flour, was still not sturdy enough to come out of the machine in a satisfactory manner.

The next experiment was with one part liquid binder and four parts of water. Making up two parts of this with fourteen parts sea sand and one-and-a-half parts flour gave a much better core than the previous one, the extra flour seeming to have caused an improvement. In his opinion that was a quite satisfactory core.

With three parts of water in the binder instead of four, and only one part of flour in the final mixture, the result was a core not strong enough to come out of the machine satisfactorily.

The result of these experiments tended to show that this liquid binder was not absolutely the best for a rotary core machine, unless one was compelled to use it.

He then used what was known as the Frazer and Chalmers' rotary core machine mixture with Corebind powder. The mixture consisted of 18 lbs. sea sand 1¼ lbs. flour, and 1 lb. Corebind powder and sufficient water. The cost of the binder and flour was, at the time the experiments were made, 5¾d., and it was found quite satisfactory for his use. The point was to find the correct amount of water, which only experience determined, the wetness of the sand being an important factor.

Detailing some of the experiments with this class of binder, Mr. Bartlett said it was found that 28 lbs. sea sand, 2 lbs. Corebind powder, and ¾ lb. flour did not produce a satisfactory core. It would not go through 2 ft. long, and that was what he was aiming at. It was not strong enough to push itself through, and the shape was distorted.

Except that it would not go through to the full length, however, it was satisfactory.

A mixture of 25 lbs. sea sand, 2 lbs. powder, and ¾ lb. flour came out a bit longer, but not 2 ft., and was distorted at the end.

A perfectly satisfactory core was obtained with 21 lbs. sea sand, 2 lbs. powder, and ¾ lb. flour, and that it went the whole 2 ft. but was slightly distorted at the end.

A mixture of a gallon of water and 2 lbs. of Binderit sold in briquettes gave an excellent result, when using one part of this solution with seven parts sea sand and one part of flour. This was not arrived at without a series of experiments, carried on in the same manner as with the aforementioned liquid binder. He would consider it was essential to have the same sand always, as he found when using other sands, the mixture wanted slight alterations. The sand must be dry, otherwise sufficient binder was not got in. It gave a perfectly satisfactory core, and he preferred it because there was no bad effect on the casting. This liquid binder always gave quite satisfactory results, differing entirely from the liquid binder mentioned previously. It was easily mixed with the sand, and had not the same tendency to sink as the aforementioned liquid binder. It was certainly, in his estimation, the most satisfactory liquid binder and substitute for oil. The cores were very similar in appearance to oil-bonded cores, and vented freely. A great advantage they had over the oil-bonded cores was the absence of the well-known objectionable odour and fumes both in the drying process and when in contact with the metal. The workmen all appreciated this mixture for these reasons, and raised no objections to using it; whereas with oil, it was not always easy to get men to work it. Cores made with it left the casting quite clean, with a perfect skin.

A core made with simple linseed oil—eight parts sea sand, one part flour and one part oil—gave a tough core, the sand being dried and the flour and oil being added in succession.

He had another powder binder which he had no information about. It was sent him from Sheffield by a gentleman who could not use a rotary core machine. He himself had made two or three cores. Twenty-five parts sea sand and one part powder gave a perfectly good core if above 1½ inches. Below that size it was necessary to use less sand. A 1¼-in. core went soft and distorted, and he could not get a ¾-in. core at all with that mixture and sand.

No matter what binders he used, he could not get a satisfactory core ½ in. diameter and 2 ft. long, except with oil.

Another core, using 20 parts sea sand and one part of the Sheffield binder, gave a stronger result, but it required careful handling.

With fifteen parts of sea sand and one part of the Sheffield binder a good core was obtained, and from the practical point of view vented easier than the others mentioned. It went through the machine well and to the full length.

Ten parts sea sand and one part binder, and sufficient water, gave a core quite perfect in shape, and it appeared to be quite perfect in every way. It was slightly too hard, if anything, on the skin, but the chief point was the cost, which, not knowing, he could not speak about.

Mention was next made of a series of experiments with the Wadsworth rotary core machine. Incidentally, Mr. Bartlett said he had another rotary core machine coming from Chicago that day. In Chicago they use 100 parts sea sand, ten parts flour and one part linseed oil, and water to temper.

When he first installed his Wadsworth rotary core machine, twelve or fourteen years ago, it was for cores, ⅜ ins. to 3 ins. diameter. He then used, as the basis of his mixture, six gallons of core sand, consisting of five parts new and twenty parts old, and one part fine sawdust. He then mixed three gallons of sea sand, one pint of core gum, 1½ lbs. flour, and four pints of oil, the whole being slightly ground. For smaller cores, 1 to 1½ in., he was recommended three quarts core sand, three gallons sea sand, ten ounces flour, seven ounces core gum, two parts oil, the whole slightly ground; but that was too elaborate for him, and he never used it. The original sand mixture used on the rotary core machine quite successfully consisted of five parts sharp sand, three parts yellow loam, one part flour, and half part flour and half part oil and water to temper.

Describing a number of other cores exhibited, Mr. Bartlett said he had used coarse builder's sand with quite satisfactory results, the cores being made in half and stuck together with core gum and water. All the cores shown were made in series of three, each of the series being of different sand, either sea sand, spent sand from the trimmers' shop, or very coarse builders' sand. Binderit was used in each case as the bond. Where it was possible to put a vent it was advisable to do so. If the mixture was right no ramming was required. In some parts of the country horse dung and a mixture of loam was used, but from the hygienic point of view it should not be used even though it cost nothing. He always used sawdust in place of horse dung; not only was it cleaner and more hygienic, it also had the advantage of being easily procurable, and practically cost nothing; whereas nowadays, owing to modern means of haulage, the difficulty of procuring horse dung was getting much more difficult than ever. He had used spent sand with binders of oil with satisfactory results, and if that could be done then something satisfactory should be obtained with every other sand. Finally, Mr. Bartlett referred to the difference of opinion among various people as to what a facing sand is.

Discussion.

Mr. W. H. Aston asked the name of the new Chicago machine mentioned by Mr. Bartlett.

Mr. Bartlett said it was termed the Hammer Core Machine. It had not yet been installed, and it had been purchased on its reputation in America, as well as a recommendation from the management of the branch of Fraser and Chalmers in the States. It appeared to be a well-thought-out machine. With the ordinary rotary core machine the screw conveyor was worked by a hand-wheel, and there was a hopper above it into which the sand was fed. At times the rod, which the operator used to direct the sand towards the conveyor, came down too far, and the conveyor got broken. In the new machine there was a self-acting gear attached, a sort of rotating mixer or whisk. This kept the sand fed down to the screw conveyor, and that was one of the advantages of the machine over the Wadsworth machine, although both were American machines.

Mr. J. Hall asked if the long cores exhibited could be cast flat.

Mr. Bartlett said they could not at the full length shown, viz., 2 ft. The machine should turn out the cores 2 ft. in length, and if they did

not come out 2 ft. long there was something wrong with the mixture.

MR. HALL asked for experience of the length that it was possible to cast on the flat.

MR. BARRETT said he had cast a 2½-in. core 10 ins. without any sign of distortion in gun-metal castings.

MR. HALL said he had heard of them being cast longer, and that when the core comes out of the machine it was necessary to rod the place where the vent is, and the core runs on to the rod.

MR. GAUNT said he had tried that, but it was impossible to get the rod to fit sufficiently tight in the hole to prevent a little arching of the whole core.

MR. BARTLETT said the vent must wobble out, because it was not so nicely pitched as to run perfectly true. The die was perfectly true, but the vent was almost like a rifle barrel if it could be looked through.

MR. ASTON asked if Mr. Bartlett would use Binderit for 2½-in. diameter cores in brass.

MR. BARTLETT said the Fraser and Chalmers brass foundry closed down some time ago, and he could not say exactly what they did then. But Binderit did make 2½ cores perfectly, in fact he made them quite perfect from ⅝ in. to 3 in., varying in ¼ in. sizes.

MR. BARRETT said the firm used all the binders with brass that they used with iron. The only thing was that when casting phosphor bronze with sharp sand it was necessary to be careful, when the core was hot, to give three successive coats of a mixture of china clay and pencil lead to prevent the metal penetrating into the core.

MR. BARTLETT said that all the time Mr. Barrett had been with the firm they had not used oil for cores with the rotary machine until quite recently. He had always used Binderit, but he had been forced to experiment with other binders because he could not get Binderit at the time mentioned.

MR. STONE said he had used oil for brass work for two or three years on castings from 13 to 18 in. diameter and square, and ⅜ to ⅝ metal, and had not been able to find anything better; just boiled linseed oil and sea sand.

MR. GAUNT said he had never succeeded in getting a 2-ft. core with the Wadsworth machine.

MR. BARTLETT said he had found it necessary to alter the dies on the Wadsworth machine in order to get the best results. It was found that with different mixtures a different length die was effective. What was effective with oil was fatal with a weaker binder. Oil was a lubricant, and helped the core to come through the die. Other binders were not lubricants without flour; that was the real reason for using flour. If the core would not go through it was found that by reducing the length of the die better results were obtained. The smaller the die the shorter it ought to be, and the larger the die the longer it should be, because volume gave strength. Similarly with the screw conveyor. If it was found that the screw was carrying too much sand into the die, a washer, or even two or three washers, at the back would probably remedy that. Many adjustments were necessary to get the best results. So far as oil was concerned he did not like it because it gave such an odour.

A hearty vote of thanks was accorded Messrs. Hayes and Bartlett at the conclusion of the discussion.

Surface Tension and Cohesion in Metals and Alloys.

The following is a summary of a Paper by SYDNEY W. SMITH, D.Sc., A.R.S.M. (London), presented before the Institute of Metals:—

The author referred to a previous communication, made by him in 1914, in which he described a method of measuring the surface tensions of molten metals based upon the observation that capillary depressions occur in the surfaces of molten metals when carbon tubes of fine bore are plunged vertically into them. These depressions were found to follow the general law by varying in depth inversely as the diameter of the tube, and to be analogous in every way to the depressions which have long been known to occur under similar conditions in liquid mercury. The property of surface tension, being the result of internal molecular forces which are unbalanced at the surface of a liquid, is now considered in relation to the internal forces of cohesion in the solid state, and from this point of view it is regarded as being an index of cohesion. The continuity of properties in the liquid and solid states has been examined by Traube in relation to Van der Waal's equation—an expression in which Boyle's law is extended to take into account the forces of molecular cohesion—in modifying the simple gas relation, $PV = a$ constant, and originally applied to gases under considerable compression. As the result of the application of this equation to the solid state, certain figures have been given by Traube for the internal pressures or internal cohesions of the pure metals, based upon their atomic volumes and co-efficients of expansion. These figures have now been compared with the surface tensions in the molten state of those metals which have so far been examined, and, with the exception of aluminium, they show a comparatively simple linear relation. From this it is concluded that surface tension in the molten state may be regarded as an index of cohesion in the solid state.

The relation of these internal pressures to the compressibilities of metals as determined by T. W. Richards was next discussed. By considering atomic compressibilities, as deduced from Richards' values for unit volume, Traube has shown that for fourteen metals in the solid state the product of the internal pressure and the square root of the atomic compressibility is roughly a constant. The significance of this relation was discussed with regard to the hardness produced in metals by cold work, and it was suggested that a closer scrutiny should be made of the small changes of density which occur as the result of such treatment.

The second portion of the Paper dealt with certain aspects of cohesion when considered in relation to the miscibility of metals when alloyed. Indications were given of the direction in which the determination of the surface tensions in the molten state may throw some light on problems which are intimately dependent on cohesion. Consideration was given to the occurrence of "liquation" resulting from limited miscibility even in cases in which the components are regarded as forming complete series of solid solutions. An explanation of this behaviour was offered, based upon the foregoing considerations. Certain conclusions were drawn as to the effects of the relative internal pressures of the components of certain alloys in determining their hardness.

Control of Cast Iron.*

By H. J. Young.

At no time has there been such urgent need for co-operation and unity between the industrial and the scientific man as at present, and the object of this Note is to record, in simple language, impressions gathered as the direct result of such co-operation and unity, as carried out at two iron foundries, one at Wallsend, the other at Sunderland.

Broadly speaking, there are three things which matter in the average iron foundry, namely, good castings, low cost of production, and suitability of the material to the purpose for which each casting is intended.

Good Castings.

Good castings depend largely upon the foundryman, and a first-class man seldom fails. His trade takes years to learn, and generations of foundry wisdom are handed down to him. Any chemist going in for foundry work who ignores or is ignorant of the knowledge and experience concentrated in the foreman makes a grave mistake. Quite equally is it true that the foundryman who similarly ignores the metallurgist is making no less an error. Mutual respect for and confidence in each other's knowledge are absolutely essential to the complete success of the foundryman and the chemist. The latter must be free to accustom himself and adapt his knowledge to the practical conditions of the foundry and the requirements of the foreman.

Dr. Stead says that in a works the chemist should be as indispensable as the timekeeper, but if the chemist is bound down to his laboratory, either by shortage of staff or by the law of the employers, then he is so handicapped as to be little more than a luxury. Unfortunately this fact is not recognised in many works.

It will take years to attain the level of scientific production possessed by Continental competitors, our present position being brought about less by want of science than by lack of appreciation and practical application.

Low Cost of Production.

Turning to the necessity of keeping down the price, we meet something at which foreigners excel. No matter whether it be a first-class article or a third-rate one, the main point is to get the best that can be got for the money.

The foundryman cannot make the best metal at the lowest possible cost, because he has not the requisite knowledge. The result is that each foreman binds himself down to certain mixtures of certain irons, as being those he can work, and there the matter begins and ends. Despite the progress of engineering, the huge alteration in temperatures, pressures and other requirements, the material of which the casting is made is often produced in the most unskilful and uneconomical manner imaginable.

In order to illustrate this point let us consider any cylinder cast from a rule-of-thumb mixture. The known facts are that according to a mixture of uncertain date and origin, two or three brands of pig-iron of uncertain composition were charged into a cupola of uncertain effect, together with some "selected" scrap of uncertain quality. Suppose such a cylinder were to give trouble, then the matter would be investigated and finally shelved, the chief engineer or the scrap being condemned according to the point of view of the parties concerned. Failures and accidents arise from some deviation from normal conditions, and entire absence of knowledge of these conditions renders investigation almost useless.

It may be argued that rule-of-thumb mixtures are based upon first-class practice, but when one takes into account the variations in pig-irons and cupolas it becomes evident that no mixture continues to give consistent results. If proof be required of this, one has only to test the cast iron from a rule-of-thumb mixture to find that its composition is constantly varying. Moreover, if a request be sent to any merchant for the analysis of an ordinary brand of pig-iron the reply is that the analysis is so and so, but that they do not sell to analysis nor guarantee it. There is no doubt whatsoever that the use of pig-iron in this blindfold manner causes cast iron to suffer in price or quality or both, and is an absolute deterrent to progress.

Pig-Iron.

Reviewing the pig-irons used in this district, the cheapest are those popularly called "local" irons, of which the following are typical examples:—

Brand	Analysis				
	Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.
"A" (local) ..	3.6–3.8	2.0–3.5	1.5–1.7	0.026–0.058	0.5–0.7
"B" (local) ..	3.8–4.2	2.2–3.5	1.3–1.6	0.031–0.057	0.5–0.7
"C" (local) ..	3.5–3.9	2.6–3.8	1.2–1.5	0.015–0.039	0.6–1.3

The pre-war prices of these were very near that of scrap. The first two are almost identical, though some rule-of-thumb foundrymen exclude one brand and use nothing but the other. As a matter of fact, either can be used, and the choice should vary with the price. The third brand is different in that it usually contains more silicon and manganese and less phosphorus and sulphur, consequently in a mixture where high-silicon "Scotch" is used as a softener, it would be cheaper to use "C" brand of local iron instead of "A" or "B," and proportionately economise in "Scotch."

The next brands are Scotch, the following being much used:—

Brand.	Analysis.				
	Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.
"D" (Scotch)	3.7–4.0	1.8–3.7	0.7–0.9	0.006–0.014	0.6–1.4
"E" (Scotch)	3.6–4.4	2.6–3.8	0.7–1.0	0.010–0.020	0.9–1.5
"F" (Scotch)	3.5–4.6	2.1–4.6	0.7–1.1	0.001–0.049	1.3–2.5

* Paper read before the Newcastle Branch of the British Foundrymen's Association, January 27, 1917.

The pre-war prices would be about 14s. above those of the ordinary local brands (A, B and C). They are all much alike, although, as with the local irons, one brand may be extolled in one foundry and condemned in another. The last kind mentioned has generally the most manganese and the first the lowest silicon. The variations in these irons are greater than in the local varieties.

Scotch irons impart no property to cast iron which cannot be obtained by means of other irons. Their use should be entirely a question of value for money, and if the Scotch iron works out as the cheapest in order to produce the required composition, then it is an excellent iron for the purpose, but otherwise it is unnecessary to use it.

The following are two well-known hematites :—

Brand.	Analysis.				
	Carbon.	Silicon	Phosphorus.	Sulphur.	Manganese.
"G" (hematite)	4.0 – 4.7	1.6 – 2.7	0.02–0.05	0.009–0.044	0.8 – 1.3
"H" (hematite)	4.4 – 4.6	1.1 – 3.4	0.01–0.06	0.010–0.118	0.7 – 1.6

The pre-war prices were about 10s. above those of the ordinary local brands (A, B and C). These hematites are much alike, the main differences being in the sulphur and manganese. They can be chosen entirely by price and used according to the composition of the consignment.

The last example is an unclassed foundry pig-iron :—

Brand	Analysis.				
	Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.
"J" (foundry)	3.6 – 4.6	1.7 – 2.4	0.7 – 1.0	0.006–0.041	1.1 – 1.4

Previous to the war such an iron could be got for about 7s. more than the price of the ordinary local irons (A, B and C).

All of the above brands have several "numbers" indicating a slightly lower or higher average of silicon, and economy can be effected by choice of "numbers" as well as brands. In choosing or using pig-iron it is a golden rule to forget names and remember only price in conjunction with quality and composition.

Daily observance of such pig-iron as those mentioned above shows that none of them possesses any property unaccounted for by the practical understanding of its composition; further, any ordinary pig-iron on the market can be included in any mixture under the control of a chemist skilled in works' practice and working in harmony with the iron-foundry foreman.

A significant fact arises from an inspection of the composition of any ordinary pig-irons over a number of consignments. The nine brands (A to J) and others have been watched very carefully, each consignment, however small, has been sampled and analysed, often re-sampled and re-analysed, until the results have been beyond doubt. One is led directly to the conclusion that these ordinary pig-irons vary so much and so frequently as to render their average compositions valueless for the purpose of producing cast iron of standard composition.

A mixture such as 5 local + 3 Scotch + 2 hematite + 10 scrap is liable to give 0.5 per cent. less or more silicon than that obtained by calculation from the average compositions of the pig-irons. Using the irons A, F, and H, and taking their average silicon as 2.7, 3.2, and 2.0 per cent. respectively, with that of scrap as 2 per cent. we find that the total silicon in the above mixture works out at 2.3 per cent. On the other hand, from the variations in the pig-irons the chances are that it may be anything between 1.9 and 2.9 per cent. This is what actually happens when using rule-of-thumb mixtures.

That the makers are well aware of this is obvious from the fact that they will not sell even to an average analysis; but it is not mentioned in their booklets setting forth the compositions and properties of their irons. The grading of pig-iron by fracture will continue just as long as foundrymen remain in ignorance of the truth. It may be said that every foundry cannot support a laboratory, but that does not apply to the iron works. If foundrymen demand material of known composition they can be supplied with it and advised how to use it to produce cast iron of approximately standard composition and properties. The astonishing part is that this blind-fold method of purchasing and using pig-iron should have existed so long.

Mixtures.

Economy can be effected by stopping the common practice of including a lot of hard iron in a mixture and then being compelled to use expensive high-silicon iron to soften it. The familiar expression, "That's a good iron, it will hold a lot of scrap," is one that brings more grist to the mill of the iron merchant than benefit to the foundryman.

The metallurgist has any iron on the market within his reach; if one goes up in price he avoids it, should it go down he buys it; when scrap is scarce he uses less or none, when cheap he uses more—always getting his mixture to the same composition at the lowest price. On the other hand, a rule-of-thumb mixture is bound down to certain quantities of certain brands, regardless of alterations in price or quality, and rarely gives metal of the same composition, or at the lowest cost.

Failures.

Attention may be turned to a more important economy. Every failure is due to a deviation from normal conditions, and the metallurgist, by daily study and observation, can ascertain the normal conditions for the metal in any particular class of work and keep every casting in line with them. Moreover, if by chance a casting infringes those conditions he can detect it before the casting leaves the works. Mysterious failures do and always will occur in rule-of-thumb foundry practice. Every failure is a terror to the rule-of-thumb man; to the scientific man it is a lesson.

Metal Suitable for the Job.

Now that engineers are becoming aware of the unreliability of cast iron they are exhibiting concern and calling for investigation. As a matter of fact, cast iron has been very badly used by engineers, and before starting investigations it would be wise to determine the effects of replacing the present haphazard methods by a system of definite control. It may be repeated that lack of records and data of ordinary practice is a bar to

progress and research. That the understanding and control of the metal does not come within the province of the foundryman is evident when one calls to mind the many unsolved problems of cast iron, as, for instance, hardness and abrasive hardness under various conditions of temperature, pressure and load; internal contraction strains; stresses caused by heat; resistance at various temperatures to bending, crushing, pulling, alternating and impulsive loads; growth and alteration of dimensions at high temperatures; the properties of conductivity and expansion at various temperatures and pressures; resistance at high temperatures to great steam or oil-gas pressures; resistance to various forms of corrosive action; and so on.

Engineers treat cast iron as an unreliable material. A huge safety factor is allowed, sections are thickened, ribs put in, steel castings substituted, and everything imaginable is done except pay any attention to the understanding and control of the metal itself.

Steel in Mixtures.

Turning again to practical considerations, the addition of steel to cupola mixtures has given rise to much controversy. Mild steel contains very little silicon and, added to a mixture, it lowers the total percentage of silicon in the resultant metal. It follows, therefore, that without knowing the composition of a mixture the addition of steel to it will probably give trouble. Some rule-of-thumb founders use steel, but safeguard it by using high-silicon mixtures, hence what they gain in one way they lose in another. About 5 or 10 per cent. of steel is beneficial to a controlled mixture in a properly worked cupola. It cannot be detected by the foundryman, and gives no trouble whatsoever. Many faults are attributed to the use of steel, but they are due to lack of knowledge on the part of the man adding it, or condemning it.

Sulphur.

Sulphur presents another problem of the same class. The foundryman knows little about sulphur except that now and again it has got him into trouble, with the result that for evermore he condemns sulphur and all its works. Practical experience in the foundry leads one to the belief that sulphur in cast iron has a great influence for good or for evil.

It is not the lowest amount of sulphur which gives the best metal and a perfect casting at one and the same time. Some castings have very thin sections combined with very thick ones, and the metal which will successfully run the casting will be weak and unreliable if the mixture is made on exclusion-of-sulphur principles; on the other hand, if advantage be taken of the influence of sulphur compounds upon cast iron, not only can a fluid clean-running metal be produced, but also a close and tough material—a combination of properties which seem impossible to obtain in certain castings if sulphur is cut down to a low limit.

Most properties of any cast iron are apparently determined by the quantity and condition of its carbon, while the production of a perfect casting depends largely upon the viscosity of the metal up to the moment of its freezing. Hence if silicon and phosphorus are to be considered as the only means of obtaining the requisite properties in both the fluid and the solid metal, then in many castings either the quality of the material or the soundness of the casting will suffer—indeed, the foundryman often sacrifices the former to gain the latter.

Another point is the peculiar habits of segregation of sulphur compounds in their relation to cases where certain parts of a casting need to be particularly hard and non-porous, and also where chillers and denseners are used. It is probable that the condemnation of sulphur is partly responsible for the unsatisfactory position of cast iron in modern engineering.

Phosphorus, Manganese and Silicon.

Phosphorus needs little comment. In ordinary commercial engineering it is not economical or necessary to reduce it far below 0.75 per cent. in the finished material, neither is it advisable nor essential to increase it much above 1 per cent. Excluding the thinnest work, the not uncommon use of very high phosphorus appears to be more often due to lack of metallurgical knowledge and cupola control than to necessity.

Manganese is important as being the link whereby use can be made of sulphur; apart from that it has no great interest when financial considerations compel it to be under 1 per cent. in the mixture, though well above 0.3 per cent. in the cast iron is advisable.

The use of silicon is so well known as to be abused, and judging from the varieties of the scrap heap the average cast iron contains at least 2 per cent. of silicon, whereas 0.5 per cent. less gives better metal and as good castings.

Carbon.

Carbon, the most important impurity, is considered hardly at all in ordinary foundry practice. In the first place, correct estimations of the combined and graphitic carbons are most difficult to obtain, and a works chemist should investigate the various methods of analysis for the carbon in cast iron, always keeping in mind the fact that methods of sampling and of analysis can suffer from "chronic inaccuracy," giving relative but not absolute results. This trouble being so common in all analytical work it is astonishing that analysts have taken no concerted action in the matter.

Secondly, the quantity and condition of the carbon in cast iron depend not upon one, but upon all the other impurities, also upon the equilibrium of the system, and finally upon the particular cupola used and the manner of using it. This remark refers not only to different types of cupolas, but to the fact that two cupolas of similar design and capacity can give different results. A simple practical example of the importance of the cupola may be obtained by putting in as the first charge on a newly-lit cupola, say, a hard liner mixture, and then later on in the day repeating the mixture in the same cupola. The result will be two cast irons different in quality or composition or both. To a greater or lesser extent this variation goes on all the time, and while it is comparatively easy to establish conditions whereby the silicon, phosphorus, sulphur and manganese may be controlled, it is far more complicated to ascertain those governing the quantity of total carbon in the ladle and the quantity and quality of graphite in the solid metal. An enormous amount of work remains to be done on cupola reactions and cupola mixtures, and the particular

part they play in deciding the final quantity and condition of the carbon.

Scrap.

Well mixed scrap iron is less variable in composition than any ordinary pig-iron, which explains why as much as 60 per cent. of it can be used without upsetting a mixture. "Carefully selected" scrap, beloved by the rule-of-thumb man, gives rise to many troubles, but, curiously enough, the scrap gets the blame, never the selection. A controlled mixture must have scrap of known composition or well mixed scrap with an average composition.

An astonishing myth is that about troubles due to scrap. It arises from and is based upon the fallacy that one can look at a piece of iron and tell whether it is suitable to go into a cupola mixture to produce metal of a particular composition. This "second sight" procedure is most detrimental to progress. Of course, it is true that sometimes one can see if an iron is very strong or very weak, but that gives no indication of its fitness to enter as the main component of a certain mixture. The foundryman or engineer who believes that he, or anyone else, can judge the properties or composition of cast iron by looking at it with the naked eye is simply labouring under the delusion that what cannot be seen does not exist. The proof of this is to put it to the test.

"Fancy" Pig-Iron.

A word may be given to certain irons which are recommended to foundrymen by means of shrewdly-worded pamphlets and even books. They resemble "patent" medicines in two ways, firstly, one and all are greatly overrated and overpriced, and secondly, genuine relief is obtained by their use in certain cases. Such an iron is the following:—

Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.
2.6–3.0	1.1–1.8	1.4–1.7	0.090–0.150	1.6–1.9

This would cost, before the war, about 33s. more than the local pig-irons (A, B and C), and as much as 25 per cent. of it would be recommended for use in a cylinder mixture. One sees that the high phosphorus will give the foundryman no cause to complain about fluidity, the low silicon will pull down the too high silicon mixtures used by the foundryman, while the high sulphur gives him the benefit of what he would refuse to use under its right name, and lastly, the high manganese provides that the sulphur shall not go astray. Altogether its effects upon a rule-of-thumb mixture are good, and the cost of the cast iron is raised about 8s. a ton. The same effects can be obtained in a controlled mixture with no extra cost, and a consideration of the composition and properties of most of these high-priced remedies will show that they are poor value for money.

Test Bars.

A final remark may be devoted to test bars. Constant inspection of test bars will be rewarded by the metallurgist becoming competent to judge the metal in a casting by test bars cast from the ladle and on particular parts of the casting. For the latter purpose the Admiralty transverse test bar is excellent, but the Admiralty requirement of 2,000 lbs. is insufficient, and a minimum of 2,350 lbs. excludes more undesirable metal than the small difference in test would suggest. Ladle tests are conveniently made on bars of the American tapered pattern. People who think cast iron can be judged by looking at it almost invariably dislike test bars. Progress is impossible unless the metallurgist can break down these prejudices without arousing others.

Scientific control is practicable, economical, and urgently needed, also that it can only be successfully carried out by the co-operation of three men—each thoroughly trained in his profession and possessing sufficient knowledge to give him respect for that of his neighbour—namely, the foundryman, the metallurgist and the engineer.

Works Extensions of Thwaites Bros., Limited.

Some extensions of considerable importance are being made to the Vulcan Ironworks, Bradford, of Messrs. Thwaites Bros., Limited.

The new steel foundry designed to meet the demand for special work is already in operation, though its equipment is not yet fully completed.

The floor, which is covered by a three-bay roof, is 170 ft. long by 90 ft. wide, the two casting floors being served by five electric cranes, each of five tons capacity (Herbert Morris, Limited). Amongst the auxiliary plant still to be installed are twelve jolt-ramming machines, by the Britannia Foundry Company, Coventry.

The melting plant at present consists of two Snyder electric furnaces, each of a nominal capacity of 30 cwts. These are worked single-phase and have each a transformer capacity of 600 kva. They are employed exclusively for melting scrap, and when in full blast give seven melts in the twenty-four hours. Up to the present it has been found possible to do all the necessary repairs during the week-ends. A third similar furnace is shortly to be installed. Adjoining the foundry is a sand-mixing shop, with a core-making shop above it.

A particularly fine machine shop, covering approximately three-quarters of an acre of floor space, has just been completed, with the necessary offices adjoining. The building is covered with a saw-tooth roof and furnished with north lights, the floor, as also the basement, being ferro concrete, whilst the bulk of the equipment comprises new machinery, for the most part turret lathes, each driven by an independent motor. Accommodation has also been provided for the reception of the machine tools from the bay adjoining the foundry, and when the transference has been made the building, 170 ft. by 30 ft., will be converted into a fettling shop. Castings from the foundry are delivered to the machine shop by an electrically-driven hoist. The swarf from the machine shop is passed down shoots into a walled-off portion of the basement, where the swarf is put through a mill, ground up, and thence fed to the furnaces by means of a rope conveyor. That this preliminary grinding is not universal when dealing with swarf is somewhat surprising, in view of its obvious advantages, as not only does it lie closer in the furnace, but it is at the same time much easier to charge.

The remainder of the basement under the machine shop forms a roomy stores for castings, while a laboratory is being erected above one end of the foundry. The test house, which has just been completed, contains a Buckton 50-ton machine, the usual hardness-testing appliances, and a very complete micro-photographic apparatus. An interesting auxiliary is a small Fletcher-Russell sand-testing furnace, which is fired by gas under pressure, and in which it is possible to obtain abnormally high temperatures very rapidly.

The Melting of Non-Ferrous Metals.

At the meeting of the Institute of Metals last month a number of Papers were submitted dealing with the subject of the melting of non-ferrous metals and the developments that have taken place as the result of recent experience, more especially as regards acceleration of output and efficiency of working. Abstracts of the Papers are appended.

METAL MELTING.

By H. M. Thornton, M.I.Mech.E., and Harold Hartley, M.Sc.

The marked success achieved by furnaces employing coal-gas as a fuel, in the heat treatment of metals such as steel, is proving of material assistance in the introduction of gas-fired, metal-melting crucible furnaces. It is proposed in this Paper to deal only with a furnace of the type intended for melting the metals of higher melting point, from brass upwards.

In working with coal-gas the fact must not be overlooked that in terms of B.T.U. available the fuel is costing from four to five times as much as coke, assuming the gas supply to give 500 B.T.U. per cub. ft. net at a cost of 2s. per 1,000 cub. ft., and even with water-gas the fuel is considerably more costly per B.T.U. than the coke which it is intended to replace. Starting with this disadvantage the furnace manufacturer has either to obtain a markedly greater thermal efficiency out of his appliance, or to effect economies in other directions.

When asked to quote fuel consumptions, the furnace manufacturer will not be able to do so unless the melter can provide some fairly precise information as to the pouring temperature required. In the authors' work with brass and copper the pouring temperature has ranged about 100 deg. to 150 deg. C. above the liquidus. In this connection it is of interest to recall the work of Mr. Lohr, in which the conclusion is drawn, after an examination of the copper-zinc alloys, that the best pouring temperature is between 100 deg. and 200 deg. C. above the liquidus, a higher pouring temperature always producing an oxidised casting. With reference to brass melting, overheating is not advisable, as there is always the danger that it will lead to honeycombing if the metal is cooled before pouring.

Brass Melting.—Starting from cold the additional fuel needed acts as a handicap in the endeavour to obtain low average consumptions, the overall effect of which is decreased by increasing the number of melts carried out successively. For the fourth and subsequent melts it is found generally that the gas consumption per lb. of metal melted remains practically constant. In the last melt of the day a small saving is effected, owing to the fact that there is no excess of brass in the metal preheating chamber, and in consequence the degree of preheating of both the metal and air increases.

In Table I. are given results of a typical run, limited to six melts to avoid repetition, and added are the average consumptions on the basis of 12, 15, and 20 melts :—

Table I.

	Gross consumption per lb. metal melted.	B.T.U. per lb. metal melted.
	Cubic feet.	
Average for 6 melts ..	2.25	1203
„ „ 12 „ ...	1.92	1031
„ „ 15 „ ..	1.86	996
„ „ 20 „ ..	1.79	962

Metal Losses.—Analyses of two brasses remelted several times (*a*) with a sawdust covering, (*b*) with common salt as a flux, indicate that the loss of volatile constituents is much the same even when the metal is rendered very hot. There is a certain amount of inconvenience attached to working with a salt covering, owing to the acid fumes produced. On the other hand, salt is stated to be useful in small quantities, admixed with charcoal to prevent absorption of sulphur by molten copper and its alloys; and to lessen the retention of viscid metal by the dross. The fluxes used more generally are calcium fluoride, glass, and potassium hydrogen sulphate. The authors incline to the view that the most satisfactory results are obtainable by the use of a charcoal or similar covering, together with a small amount of flux. In an inert atmosphere the rate of loss of zinc from a given brass will depend on the temperature and the speed of flow of the gases over the metal. During melting the process may be accelerated owing to the oxidation of the zinc vapour and consequent reduction of the partial pressure of the metallic vapour. The effect of this latter factor is decreased to some extent if the combustion of the gases is not completed in the pot chamber, and still further if a covering of charcoal is employed. In the final heating stage, after the metal is molten and when the greatest loss occurs, a crucible lid previously heated in the metal preheating chamber can be used to cover the pot and decrease the loss.

Assuming that it requires in the respective furnaces 3.0 cub. ft. of coal-gas, or 0.5 lb. of coke per lb. of metal melted; then if the gas is burnt completely to CO_2 in the pot chamber, the volume of products (calculated at 0 deg. C. and 760 mm.) will be about 14 cub. ft., whereas with the coke if it burns to CO_2 there would be about 77 cub. ft. of products, and if only CO were formed, about 45 cub. ft. From three to five times the volumes of products flowing through the gas-fired furnace pass through the coke furnace.

The authors have investigated the question of zinc losses in connection with gas-fired furnaces. In making up a red brass containing a little tin in four 50-lb. lots, they found the average zinc loss not to exceed 3.0 per cent. With regard to the zinc loss on remelting yellow brass, the following tests were made :—Two 70-lb. lots of works scrap brass A and B were melted and cast into chills, sample ingots being retained for analyses. Batch A was then remelted with a covering of sawdust only, cast into ingots, a test ingot withdrawn, and the

remainder returned to the crucible, remelted, and a further sample taken. This treatment was repeated, five remelts in all being made. In the last melt, after the pourers had approved the metal to be sufficiently hot for casting purposes, the crucible was left in the furnace for another half-hour, the temperature of the metal being raised steadily during the whole of this period. The second batch of metal B was treated in a similar manner, except that in this case a covering of common salt was employed, and no provision of charcoal made for the prevention of oxidation. In neither case was a crucible lid used. The test ingots weighed about 3 lbs. each. As a result of these tests it was found that with a low pouring temperature, *i.e.*, 1,000 deg. C., the loss of zinc need not exceed 1½ per cent. of the zinc originally present. With a red brass poured at 1,090 deg. C., the loss was somewhat higher, whilst when the temperature of a yellow brass was raised to 1,180 deg. C., the zinc loss rose to about 6 per cent.

Melting tests with copper proved how important it was to load up the pot as much as possible if the most economical melting is desired. Materially better results were obtained when the charge was mixed scrap and ingots than when only sheet scrap was handled.

Thermal Efficiency.—From the results given for brass, combined with those obtained with copper, it is possible to arrive at an estimate of the additional gas consumption necessary to heat the brass to a considerably higher temperature. If it be assumed that the specific heat of brass is the same as that of copper (at ordinary temperatures this is very nearly so), and that the heat allowance to be made for the liquefaction of the brass is 38 K.C.U. per kgm.; then the steady state efficiency during the fifth brass melt (metal poured at 990 deg. C.) will be 30 per cent. Over-all efficiency for six brass melts (990 deg. C.) will be 21.3 per cent. To get the brass to 1,090 deg. C. would require about 1,456 B.T.U. per lb. (364 K.C.U.). With an increased number of melts the actual extra gas used on the basis of the average for the day's work decreases, but still remains about 20 per cent. more than that required for 990 deg. C. As regards copper, with 560 B.T.U. gas the six melts were done at an average consumption of 2.25 cub. ft. per lb. gross, equal to 1,200 B.T.U. per lb. of metal melted, from which it would appear that, roughly, the thermal efficiency of the gas furnace is about five times that of many coke furnaces, the latter converting approximately 4 per cent. of the available energy into useful work.

The results were obtained by the authors in a gas-fired furnace, with an arrangement for preheating the metal prior to charging, and for preheating the air supply before it was admitted to the blast burner. A simple calculation shows that preheating can effect a considerable saving of fuel. In actual practice with brass the following results were obtained, pouring at about 1,000 deg. C.:—

No. of melts made consecutively ..	4	6
	Gas consumption per lb. of metal melted	
No preheating (*a*)	3.10	2.91
Brass preheated (*b*)	2.72	2.48
Brass and air preheated (*c*) ..	2.42	2.17

The actual consumptions in cub. ft. per lb. for the fourth melts were:—(*a*) 2.52; (*b*) 1.99 (*c*) 1.66. Thus it is evident that for brass melting the most suitable type of furnace to be employed will depend upon the number of melts required daily, as when only a few melts are required the additional capital cost involved in the introduction of the preheating device may not be compensated for adequately by the gas saved.

Increased Life of Pots.—A well-made graphite crucible is capable of withstanding very sudden temperature changes to an almost surprising extent. According to Mr. Downs, in actual commercial use for melting purposes a crucible has been known to stand from 80 to 100 charges in melting copper or a similar metal. Many melters, however, only claim about 30 melts per pot. In a gas-fired furnace the abrasive action of the solid fuel is eliminated, the direction of flow of the gas stream is under better control, the sulphur content of the fuel is very small (about 30 grains per 100 cub. ft.), there is no fire to poke, and clinkers have not to be removed from the outside of the pot, so that it is not surprising that long pot lives can be obtained, especially in the absence of fluxes, or with a flux which does not attack the crucible walls viciously.

Increased Output.—The average time for the actual melting operation is, for 12 melts of 68 lbs. each, 30 minutes, and for 15 melts, 37 minutes, making no allowance for the time required to pour. Under similar conditions 55 minutes would probably represent an average for many coke-fired furnaces. It should be noted, however, that the authors' results for gas consumptions have all been obtained in the works of the Richmond Gas Stove and Meter Company, by members of their staff, and are not to be regarded as representing "works practice," as ordinarily understood.

Description of Furnace.—The metal melting referred to in this communication has all been carried out in a Richmond 70-lb. crucible furnace of the preheating type. The gas and air mixture is admitted through a suitable blast burner and the lower portion of the combustion chamber, and is burnt in the annulus between the crucible and the furnace wall. The gases, after travelling around the pot, are directed through the metal preheating chamber, and then pass on to the air pipes, and finally to the flue. This arrangement enables a high degree of preheat of the metal to be obtained. The top of the metal chamber is on a level with the top of the pot chamber, and is closed by a pair of lids. With this construction the operator has not to lift his metal above the foundry floor level, and the transference of preheated material to the crucible is done with ease. The lower portion of the wall of the combustion chamber is constructed of suitably shaped blocks of a specially refractory nature to enable greater resistance to be offered to the combined action of high temperatures and spilt metal. The bottom of the chamber can be removed for the recovery of spilt metal.

METAL MELTING AS PRACTISED AT THE ROYAL MINT.

By W. J. Hocking.

Standard gold, silver, bronze and cupro-nickel are melted at the Mint and cast into bars for coinage. The castings are of comparatively small dimensions, and are in the form of thin rectangular strips about 2 ft. long, varying in width and thickness.

In melting precious metals for coinage work, the

correct proportions of the gold-copper and silver-copper alloys must be maintained within the restricted limits of variation prescribed by law. For this reason the volume of the charge is limited to one which can be conveniently stirred and manipulated with a view to the production of bars uniform in composition. For gold the weight of the charge is 2,800 ozs., for silver about 6,000 ozs., and for bronze and cupro-nickel about 400 lbs.

Coke furnaces were in use until 1910. The melting department was then enlarged and re-built, and, as the result of a series of experiments, furnaces, fired by low-pressure gas and air, were introduced. Urgent demands for gold coinage arising during the re-building operations an improved gas-melting plant was installed in a disused smithy, with a floor-space of 860 sq. ft. only. In the course of a year and nine months 874 tons of standard gold, amounting in value to 111,000,000 sterling, were melted. As a test of the efficiency of the four experimental furnaces in use, a continuous run of melting was maintained for 27½ hours. The total amount of gold melted was 257,052 ozs., or 7.87 tons, which is upwards of 1,000,000 sterling in value. There were 102 pourings, and the consumption of gas was 32,000 cub. ft. The furnaces were in a condition to resume work on the following day as usual.

New Furnaces for Melting Silver and Bronze.—The larger of the two new rooms for melting operations was completed before the close of the probationary period in the smithy, and work was commenced therein in January, 1911. Sixteen furnaces are constructed in line near the centre of the room, divided in two batteries, one of ten and one of six. The furnaces are built of Stourbridge firebrick, each well being 19 in. in dia. and 32 in. deep. The wells are lined with circular bricks, 3 in. thick, jointed with a refractory material composed of carborundum, firesand, and silicate of soda, which is also used as a backing for the bricks. The face of the bricks forming the interior of the wells is treated with a wash made up of the same materials. The whole mass of brickwork is braced together by a framework of iron bars to resist expansion, but is not enclosed with iron casing. For convenience the furnaces stand 27 in. above the floor level. The tops are covered with cast-iron plates, 1 in. thick, bedded upon a ¼-in. layer of asbestos cement. The plates are fitted loosely in sections to admit of expansion, and are shaped to allow a lip of brickwork around each furnace hole, 4½ in. broad. This ring of brickwork is made to rise slightly above the level of the iron tops, and serves to prevent the fusion of the iron coverings. The tops were at first carried to the edge of the furnace holes, and the molten iron scored the face of the furnace linings, necessitating frequent renewals. A circular firebrick, 27 in. in dia. and 3 in. thick, is used to close the mouth of the furnace hole during melting. This cover is surrounded by two semi-circular iron bands, ¾ in. thick, bolted together to form a frame. The cover, which weighs 1½ cwt., is lifted and wheeled into any desired position on the furnace top by means of a specially designed truck.

An electric-driven overhead travelling crane of 5-cwt. capacity hoists the crucible of molten metal from the furnace, and transports it to one of two pouring frames. The movements of the crane are directed by means of switches situated at two platforms. When in position for pouring, the crucible is gradually tilted by worm gearing connected with the frame through a quadrant, and the contents poured into iron moulds. The moulds are set up in batches of about forty in wheeled carriages which travel on a permanent track laid lengthwise of the room with a turntable and side-track at one end. During the process of pouring, the forward motion of the carriage on the rails as the moulds become full, as well as the upward movement of the crucible, is secured by rack and pinion gearing attached to the frame, the motions being actuated by separate wheels, controlled by two workmen.

Fuel Supply and Combustion.—Experience gained with the use of gas fuel in the temporary gold-melting house pointed to the desirability of securing a liberal supply of gas at a constant pressure. The supply of gas under these conditions was undertaken by the gas company. In the large house the gas is delivered at the furnaces at a steady pressure of 3 in. of water at the furnace, As the total consumption of the 16 large furnaces is about 15,000 cub. ft. per hour, the provision for delivery is well in excess of the requirements. An ample reserve is considered essential to uniformity in results.

Three rotary blowers of the Reichhelm type are used to supply air for the burning mixture. Each blower is capable of delivering 36,000 cub. ft. of free air per hour at 2½ lbs. pressure. All the pressure blowers are motor-driven, and two are coupled to feed the larger battery of ten furnaces. The maximum horse-power required to supply air under pressure for the whole of the furnaces in the large room is 45. The air and gas are supplied by pipes laid below the ground level in a trench running parallel with the back of the furnaces. The sizes of these pipes are sufficiently large to admit of one or more furnaces being thrown in or out of action without disturbing the steadiness of the supplies to the remainder; that for air is 9 in., and that for gas is 5 in. to the larger battery and 4 in. in dia. to the smaller. Connecting pipes from each of the two services are attached to a horizontal girder for support, and conduct the air and gas into a Brayshaw mixer. The pressures are 3 in. for gas and 2½ lbs. for air. Check gauges are in use to see whether these pressures are obtained at the furnaces.

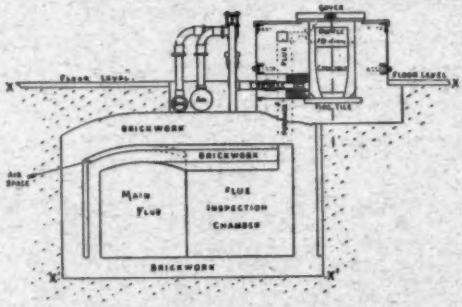


FIG. 1.—SECTIONAL ELEVATION OF FURNACE.

Fig. 1 is a sectional elevation of the furnace, showing the crucible, muffle and cover, the gas and air pipes with nozzle and burner brick in position, and the main flue with its connections. Fig. 2 is a back elevation, showing the gas

and air pipes with quadrant taps, and the girder support.

Fig. 3 shows a plan of two furnaces without their covers, each containing a crucible. One shows the top view with flue, and the other the bottom with nozzle and burner block. The admission pipes to the mixing chamber are fitted with valves, the levers of which move over a graduated quadrant. With well-constructed taps of this description the supply of gas and air can be regulated with precision. In the course of a heat these supplies require adjustment as the temperature rises in the furnace. From the mixing chamber the gaseous fuel passes through a right-angled elbow pipe, 2½ in. diameter, to the furnace. To adjust the length of flame to the capacity of the furnace and secure greater melting efficiency, the internal diameter of this pipe was reduced at its extremity to 1¾ in. The method of inserting the nozzle of the burner into the wall of the furnace, illustrated in Fig. 4, is the one yielding most satis-

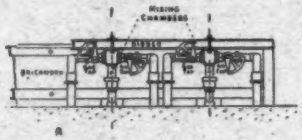


FIG. 2.—BACK ELEVATION OF TWO FURNACES.

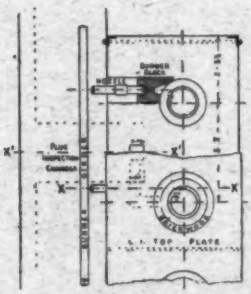
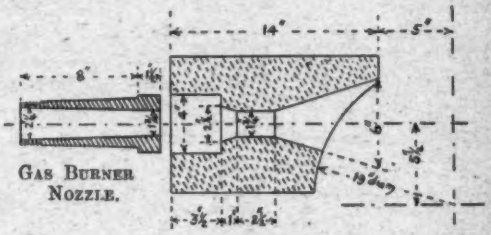


FIG. 3.—PLAN OF TWO FURNACES.

factory results. An 8 in. end-piece, screwed in position and having a diminished bore, forms the nozzle, which is increased to 4 in. in outer diameter at its extremity. It is easily detached and renewed in the event of corrosion or partial fusion.

The ignition hole of the furnace consists of a perforated firebrick of special shape as shown in the sectional drawing given in Fig. 4. A circular recess, 4 in. in diameter, at the back of the block, which is 9½ in. square on the face, receives the iron nozzle which fits the recess closely, and is surrounded by asbestos packing well rammed in. The comparatively large block of firebrick serves to keep the nozzle relatively cool. At the bottle-neck the inlet is 1¾ in. in diameter, corresponding with the bore of the burner. The passage then opens out at an angle of 30 deg. into the well of the furnace. The burner block is set to one side of the horizontal axis of the furnace well into the brickwork in a position to induce the flame to pass between the crucible and the side of the furnace without impinging upon either. The crucible is placed centrally in the furnace upon a graphite stand, 10 in. in diameter and 2¼ in. thick. A plumbago muffle or collar, 8 in. deep, rests on the crucible to increase its initial capacity, but no cover is used for the charge during melting in the case of silver and the baser metals. About 3 in. clear space is allowed round the crucible at its greatest diameter to admit of the lowering of the tongs which lift it from the furnace for pouring. When the furnace is closed the top of the muffle is within 2 in. of the cover.

The gas flame on leaving the ignition hole travels round the crucible in an upward double spiral. The best results in economy and efficiency are obtained when combustion is complete in the furnace itself, no flame being emitted under the furnace cover nor carried into the flue aperture. To reduce the length of the flame, which grows as the temperature in the furnace rises during the progress of the melt, the supply of gas and air is reduced. The flue aperture is 4 in. by 2 in. in sectional area, with its axis 5 in. below the iron covering plates, and opens into a horizontal duct leading from the furnace to a vertical shaft, 6 in. square, which serves two furnaces, and is connected with the main flue below the floor level. The main flue before entering the chimney shaft passes through a con-



FIREBRICK BURNER BLOCK.

FIG. 4.

densing chamber provided with baffles to intercept any solid matter carried off by the flue gases.

Furnace Management.—For the prevention of accidents in the use of the large volumes of gas and air delivered to the furnaces, a recognised system of workshop procedure was necessary. The following routine works satisfactorily. All the air valves are opened, and the blower is then started to deliver air to the furnaces. Then, dealing with each furnace successively, the air valve is closed, the gas valve opened, the gas ignited, and the air valve re-opened to its utmost capacity. So soon as the whole series of furnaces is alight, the gas and air taps are adjusted to produce the proper burning mixture in each case. In shutting off a single furnace the gas valve is first closed, and then the air. When dealing with the whole battery, the gas valves are closed on all the furnaces, the pressure blower stopped, and the quadrant taps turned off. Should the blower stop unexpectedly through a breakdown all gas and air taps are closed immediately. In view of this emergency the air pipes are, in some cases, provided with non-return valves which are automatically brought into action as soon as the pressure ceases. Experiments are in progress to devise a simple and effective form of safety gear for such a contingency.

The furnace linings receive close attention, which is repaid by a lengthened life. The surfaces are kept free from excrescences which would obstruct

the free passage of the flame. Accumulations of slag at the bottom of the furnace are cleaned out at frequent intervals. Faults in the brickwork are patched immediately. As a general result the entire lining of a furnace is renewed two or three times a year.

Ventilation.—Provision is made for the ventilation of the melting house by three Blackman fans, placed one at each end and one at the side, near the roof. These can be used either for supply or exhaust, as required. If two of the fans are drawing from the room, and one is discharging into it, the whole volume of air is changed every five minutes, independently of the doors, windows, and skylight.

Comparison of Costs of Melting.—Records are kept in the department of the results of melting with gaseous fuel for comparison with similar results obtained with coke. These results are available for a period of five complete years, both for gas and coke. During the five years, 1911-16, nearly 10,000 tons of metal were melted and cast into bars for coinage with a total consumption of 121 million cubic feet of gas. A comparison of the records for the two periods shows an economy in favour of gaseous fuel under each of the following heads: (1) Rate of output, (2) cost of fuel, (3) cost of graphite goods, (4) cost of labour.

(1) *Rate of Output.*—Except for gold, crucibles of the same capacity as formerly were used, but the time required for the heats was shortened considerably. The rate of output per furnace in the working day was correspondingly increased, and this increase was especially noticeable in the case of bronze, 157.7 per cent., and cupro-nickel 161.1 per cent.

(2) *Cost of Fuel.*—The respective costs of coke and gas vary considerably in different localities. They are also liable to vary in the same locality during a given period. During 1905-9 the price of best foundry coke delivered broken for use at the Mint fluctuated from 35s. to 42s. 4d. per ton; while during 1911-16 the discount price of gas per 1,000 cubic feet varied only very slightly from 21d., except during nine months of 1915-16, when it was 18.2d. Although the price of gas advanced 12½ per cent. during the last five years, the net cost to the Mint remained practically stationary owing to the sliding scale of discounts allowed by the gas company. On the total expenditure for fuel for the two periods of five years a cash saving of 3½ per cent. on the amount consumed per ton melted is shown for 1911-16. The amounts melted and the fuel consumed for the two periods are shown side by side.

	1905-9.	1911-16.
Gross amount of metal melted ..	4,833 tons	9,899 tons
Total consumption of fuel ..	2,677 tons	121 million cub.ft.
Consumption of fuel per ton melted	11 cwt.	12,220 cub. ft.
Cost of fuel per ton of metal melted	21.3s.	20.58s.

(3) *Cost of Graphite Goods.*—The crucibles used for both the coke-fired and the gas-fired furnaces were of the Morgan Salamander brand, the mixture being modified in the latter case to suit the firing. A considerable extension of life was found when they were used with gaseous fuel.

The total inclusive costs for the two periods are placed side by side, and show that the rate per ton melted has been reduced by about one-third.

	1905-9. (*Coke Fuel*)	1911-16. (*Gas Fuel*).
Weight of metal melted	4,833 tons	9,899 tons
Total cost of crucibles, etc. ..	£9,625	£13,295
Cost of crucibles per ton melted ..	39.8s.	26.8s.
Rate of reduction in costs ..		32.6 per cent.

The figures for costs shown cover in each case the purchase of muffles, covers, stands, and stirrers as well as crucibles.

(4) *Cost of Labour.*—Coke fuel necessitates considerable handling; gaseous fuel is delivered at the furnace without manual labour. During 1905-9, the average annual consumption of coke was 535 tons. Two men were employed in each melting house to transfer the coke from the store to the furnaces as required and to remove the ashes and clinker. This labour, as well as that of periodically feeding the furnaces, was abolished with the introduction of gas fuel. The coke store was no longer required for this purpose, and this valuable floor space was embodied in the main furnace room. Taking the staff as a whole, the number of men required for a given out-turn of coinage bars was reduced by the change of practice at the rate of about 20 per cent.

Power.—The chief item of cost occurring with gaseous fuel but not with coke arises in the provision of power for the pressure blowers. This item, however, is a comparatively small one. In the large room the electric current supplied is at the rate of 2 B.T. units per furnace-hour. The all-round cost for power is estimated to be at a rate not exceeding 2s. per ton melted, taking the current at 2d. per unit.

In connection with the general subject of costs, it may be of interest to state the initial outlay made in providing the new buildings with the plant specially required for melting with gas. The cost of the motors and blowers, the four 1,000-light gas meters, the pipes and connections for the gas and air services, and the burners with their accessories, was £1,984. The capacity of this melting plant under ordinary conditions is represented by an annual output of about 2,000 tons.

(Further Papers will appear in our next issue.)

ELECTRIC STEEL PROGRESS.—The adoption of the electric method of melting by the Sheffield steel trade continues to make rapid progress. Messrs. Kayser, Ellison & Company, Limited, Carlisle Works, Sheffield, have placed an order for a 10-ton electric furnace of the Greaves-Etchells type—in addition to the one of 30 cwt. capacity, which it is expected will soon be running. One of the same type of 3 tons capacity has been ordered by Jno. Hy. Andrew & Company, Limited, of Toledo Works, and 30-cwt. furnaces have also been ordered by Thos. Andrews & Company, Limited, Sheffield, and Accles & Pollock, Limited, of Birmingham. A small type of Greaves-Etchells furnace at the works of Spear & Jackson, Limited, Sheffield, has now made over 1,050 heats of high-speed steel, and the lining has only once been renewed. A further larger furnace of this type was successfully started up for this firm last week; also a furnace at Samuel Osborn & Company, Limited, Sheffield. Messrs. T. H. Watson & Company (of Sheffield), Limited, the proprietors of this furnace, are negotiating for many more furnaces; the number already at work or about to be installed exceeds twenty, and there is no doubt that the electric furnace has a great field before it. It is the only type of furnace that can readily melt the whole of its charge in the shape of turnings, etc. All other furnaces can only use a very limited quantity of turnings, and the remainder must be new raw materials, pig-iron, etc., which require ship room and rail carriage. The electric furnace can make sound steel or castings directly from turnings, and the ideal scheme would be to erect these furnaces wherever there is an accumulation of turnings or steel scrap, and a supply of electric current.

Mechanical Tests for Cast Iron.

(*Continued from page* 137, *March issue.*)

Discussion at Birmingham Branch of the British Foundrymen's Association.

THE PRESIDENT (Mr. J. Shaw), opening the discussion, said the Paper had shown up the absurdity of a standard breaking load for all thicknesses of metal from test bars of the same size. He quite agreed that foundrymen should table their ideas, either by making the size of the bar bear some relation to the thickness of the casting it represented, or, as in the American specifications, varying the breaking weight demanded in proportion as the casting was thinner or heavier than the section of the test bar. The investigations of Drs. Stead and Harbord on the influence of the shape of test bars on the mechanical properties of cast iron, made on the standard bars of English, German, and American section, indicated that, broadly speaking, the shape of the bar had little effect on the physical properties, providing the bars were all sound. But it would appear that there was a little more difficulty in ensuring sound bars cast to the English section. At the same time, they did not consider it desirable that any bar should be less than 24 in. long for the deflection test. An international bar of 20½ in. long by 1.2 in. diameter, tested at 18 in. centres, was to have been submitted at the congress to be held at Petrograd, but, of course, the war postponed that meeting. Mr. Cook mentioned the importance of knowing the total carbon content of a metal. He (the speaker) would call their attention to samples of pig-iron, one containing Si. 0.18 and the other Si. 1.96, and both showing an open grey fracture. He would defy anyone present to prove which was the iron of low silicon. That also indicated how little fracture was to be depended on, and also showed how careful one must be in using silicon control without a full knowledge of the quantities of the other metaloids present. With regard to casting temperatures, Damour experimented on test bars at various temperatures between 1,260 deg. C. and 1,030 deg. C. The temperature was taken in the ladle at the moment of casting. Starting at 1,250 deg. C. he found there was a general rise in the breaking weight of both transverse and tensile bars till the metal dropped to 1,190 deg. C. Then there was a fall, till in bars cast at 1,100 deg. C. the strength was only equal to that of bars cast at 1,250 deg. After that there was a quick fall in strength. The same author noticed the notable and always injurious influence on the strength of the bar caused by the groove left by the cutting tool when turning, which was abolished when it was carefully polished with emery paper.

PROFESSOR TURNER touched on Mr. Cook's remarks made in reference to some of his (Professor Turner's) earlier work. He was glad to know that the statements made were still true. Its trustworthiness depended on several facts. In the first place, they were able to carefully analyse the material used. He had further the opportunity of having his own analysis checked by Mr. Walkton, who was an analyst of experience, and they found they generally agreed very well on all the bars. Then they had the bars cast in duplicate, and if the results did not agree they cast other bars until they got, with the same compositions, results which were concordant. Lastly, and perhaps most important, was the fact that the mechanical tests were made under the direction of Sir Alexander Kennedy, although they were actually done by their own Professor Birstall, of Birmingham, who was then working as assistant to Professor Kennedy in London. The latter suggested the form of test bar which should be used. That bar was twelve inches long in the clear. There was a bulb at each end, and the ball joint allowed a straight pull. A number of tests had been made with various shaped bars. Sometimes the bar was rectangular. In no case did the observers get unconcordant results, and it could not be shown that there was any close connection between chemical composition and the tests of the bar. Cast iron was not ductile, and the result was that one side of a rectangular bar would give way before the other side had got its proper pull upon it, if they did not get it perfectly straight. Crystallisation would also be a cause of weakness. Mr. Cook had referred to the question of the influence of combined carbon and as to what proportion of combined carbon would give the best tensile results. He was very much interested to see that the author had given figures somewhat different from those given in his (Professor Turner's) book. The latter were the result of practical tests.

He (Professor Turner) made a collection, not only comprising his own experiments, but including those made with iron from different sources, all being results recorded by careful observers in England and America. From those he deducted a kind of general average. The metal was always strong material, and not infrequently best selected cold-blast iron, or iron of similar character not very high in carbon. His idea was that if the highest tensile strength were desired, one must get very near to the point where nearly all the combined carbon present was in the form of pearlite. Cast iron might be regarded as merely one end of the iron-carbon series, with steel at the other end. If carbon were added to pure iron the tensile strength increased until about 0.9 or so of carbon. After that the addition of more carbon decreased the tensile strength, because at that point the cementite began to separate, and cementite was hard and brittle as compared with pearlite. On the other hand, if one of the crystal areas in a sample of soft steel were examined fracture would be found taking place in the soft steel, as Rosenhain had shown, through the ferrite because it was weaker than the pearlite. Iron to which more carbon had been added than was necessary to give pearlite had brittle cementite, with the result that fracture was likely to take place through the cementite in preference to the pearlite. If the whole of the material could be kept at pearlite there was got as nearly as possible the greatest strength. The proportion of the combined carbon that could be obtained to the pearlite would depend to some extent upon the amount of the other elements present. With much silicon present the silicon would tend to throw the carbon out of solution, and diminish the proportion of carbon in the form of pearlite that could remain. Similarly,

manganese, sulphur and other elements would affect the amount of carbon present. On the equilibrium diagram of the iron-carbon series the pearlite point was represented as at about 0.9, or 1.0 of carbon.

As to the hardness test, there was a difference of opinion as to what hardness was, and whether it could be measured. He (Professor Turner) had suggested, in a Paper recently read before the local section of the Institute of Metals, that the first thing to do was to decide what was meant by hardness, and to define it carefully. There would probably then not be much difficulty in determining some method of measuring the property actually defined. Many things which had been spoken of as hardness were really not hardness at all. For example, wearing properties of metal, and resistance to rubbing and friction were not hardness. It was quite true there were hard materials which were really hard and had good wearing properties. It was also true there were soft white metals which gave good wearing surfaces. For materials to wear away quickly two things were necessary. In the first place, it must be possible to detach the particle of the material standing up to the tool, or whatever came against it so as to be detached. Secondly, those particles taken from their original positions must be entirely removed. In many cases that was not done. Take, for instance, a piece of lead or copper. If an attempt were made to wear it, the edge of the metal would be deformed, but would not be taken away. It would stick to the tool or to a piece of emery paper. It did not conform to the second requirement, that particles must not only be removed, but taken right away. In the case of good cast iron, having a good polishing surface, it was because the particles were not carried away that cast iron made such a good wearing surface. The polish was assisted by the presence of graphite—that had a smooth surface and the metal was not rapidly removed. It was possible to have soft metal with a wearing surface lasting longer than hard. Professor Arnold had shown recently that Brinell hardness did not correspond to the cutting properties of special steels; in other words, steels that would cut best were not those which gave the highest Brinell hardness. He (Professor Turner) adopted as the definition of "hardness" the property by which one body penetrates another, or conversely the property by which it resists being penetrated. Then one had only to measure the force necessary to penetrate a unit of the surface, or to resist penetration, and put them in equilibrium, and the measure of hardness was obtained. From that point of view, the Brinell test for ductile materials would constitute an almost perfect test. In the case of cast iron, which was not homogeneous, and where there were little flakes of graphite or phosphorus eutectic, or of cementite, when tested it might not show a uniform indentation; the ring was apt to be somewhat out of shape, so it was difficult in that case to get a really accurate measurement.

Mr. R. Buchanan referred to the matter of specifications giving the analysis in regard to the amount of phosphorus required in the casting. He recalled, two or three years ago, a Birmingham ironfounder telling him about some castings which had just been rejected. They were required to have not only physical tests, but chemical tests. They stood the physical test quite successfully, but as the phosphorus was 0.82 instead of 0.80 they were rejected. That was perfectly iniquitous, and he thought the attitude of the inspector was the measure of his ignorance. He (the speaker) had seen a simple form of drop test by means of a ball, but as regarded its accuracy he could not give any assurance. For shop purposes, however, it might be useful. The user had a plate, which was adjustable on slides, and there was a round hole in it. The ball was allowed to fall down through this hole, which was slightly larger than the ball, and the impact got in that way.

Mr. Broughall said he was sorry not to be able to agree with the author on the subject of drilling tests. He did not believe the drill test was a correct test at all, either for the hardness or the density of cast iron. Mr. Cook had stated that the twist drill used in making the test must be ground correctly. But how many foundries were equipped with a machine which would correctly grind a twist drill? Drilling was claimed to be a test particularly suitable for determining the density of cast iron. They knew, however, that bars cast in permanent moulds were considerably denser than bars cast in sand moulds, and a bar cast in a permanent mould drilled much easier than a bar cast in a sand mould. As a matter of fact, it was possible to drill permanent-mould castings at three times the speed the same iron cast in sand moulds could be drilled. This was a very strong point against the use of the drilling test for density. His opinion was that by using Keep's test systematically one could get far better results for hardness than by the use of the drill test. He had used Keep's test every day for the last twelve years, and had kept a record of every mixture that had been put on the cupola during that period, and it was found that this method of testing gave everything that was necessary for determining the density, strength, and hardness of the various mixtures used. Another disadvantage of the drilling method was that it took considerably longer to get results than did Keep's method. It was his own practice to examine the Keep's test bars early in the morning, and as this only took a very few minutes the result of the previous day's blow was known quite early in the day. Mr. Cook had mentioned how difficult it was to measure the indentation made by the Brinell machine. With this, however, he did not agree, as this indentation could be easily and accurately measured by using a suitable microscope with graduated scale. In regard to the machining of transverse test bars, his own practice was to cast these bars 1¼ in. square and to machine them down to exactly 1 in. square. There was no doubt that the casting of bars 1 in. square without any allowance for machining was more of a fake than anything, in order to show a higher test than a bar machined exactly to 1 in. square would. As to specifications, there was no doubt that the specifications given to foundrymen were ridiculous, for the reason that one specification was given to cover all sizes of castings. Foundrymen knew that this was altogether wrong. His (the speaker's) practice was to use five different mixtures for different classes of castings, these mixtures varying from very soft irons for thin castings, such as small pulleys, to extremely hard irons for such castings as lathe beds.

Mr. A. Harley referred to the special-shaped casting that Mr. Cook had described in his Paper, showing the effect of different casting temperatures. He had made two of these castings himself on the previous day, and brought them for inspection. One of these had been cast as hot as possible and the other as cold as possible. The silicon

in the iron was 1.5 per cent., and the pieces had been broken in the way Mr. Cook described. All the pieces showed a perfectly sound fracture, and personally he could not see the slightest difference in these fractures. In other words, with this particular metal, at any rate, there appeared to be no variation at all in the fractures corresponding to the temperatures at which they were cast.

Continuing, the speaker defended the Brinell test for hardness. He used the Brinell test regularly, and mentioned several tests he had made to find if there was any variation with different observers in the readings. In every case the same readings had been given. He doubted whether the special method mentioned in the Paper was any improvement on the Brinell. With regard to the standardisation of test bars he rather agreed with Mr. Shaw's remarks. It was very difficult to standardise a particular size of bar which would be satisfactory for all classes of castings. If one size of bar was made, different specifications would have to be standardised according to the section of the casting. Failing one standardised size of bar, the only other method that seems practicable was to have various standard bars which would approximate to some extent to the section of the casting. There was a tendency in this direction in regard to high-class castings of light section.

Mr. Cook, replying to the President's suggestion that the same bar should not be asked to give the same results for different classes of work, expressed the opinion that there should be a standardised bar to give different results for different classes of iron. In every case it must be remembered that mechanical tests were comparative, and the bar should be cast always in the same way as far as possible, and the result should vary according to the requirements of the casting being made. He thought, ultimately, that would be the way in which the ideal would be attained. The President had pointed out, by the specimen of pig-iron exhibited, how difficult it was to judge by fracture. He (Mr. Cook) had worked out the equilibrium of the silicon and carbon in the specimen, by the formulæ given in the Paper, and the result was a figure of 0.87. The metal was, therefore, a little stronger than necessary for pipes, but not strong enough for cylinder work, and this had proved to be the case in the actual castings made from this iron. The formula, therefore, remained correct even in an extreme, or "freak case," as this one undoubtedly was. Reference had been made to the effect of the casting temperatures, and results had been shown in which the highest temperature did not give the best tensile strength. His own experience was that the best results were got when the metal was poured as hot as possible from the cupola, provided it was not actually boiling. If the metal was boiling low results were got, and it was only when it was just below the boiling point that the best results were obtained. Professor Turner had said that the best tensile results were obtained with metal containing the largest areas of pearlite. He (Mr. Cook) had a micrograph of a bar which broke at 19 tons per sq. in., in which the greater part of the matrix was of a pearlitic nature with the graphite in a very finely divided form, which bore out the Professor's suggestion. The formula given in the Paper for the equilibrium of the silicon and carbon was based on the pearlite idea, the 4.6 being the carbon content of pearlite.

The difference between the quantity of CC recommended in Professor Turner's book and that suggested by the author was due, he believed, to the fact that the former were obtained some years ago, when the total carbon in the iron was lower than the amount usually met with to-day, when the irons made were much stronger and of a cold-blast nature. In the present day these cold-blast irons were not generally obtained. He (Mr. Cook) also agreed that the amount of wear obtainable might represent no measure of the hardness of cast iron. Experiments made in the works had proved that. In fact, some of the hard specimens tried wore away like pumice stone, whereas some of the soft ones gave quite as good results as the best hard ones. It was necessary that the metal should spread under work and give a good surface polish, if good results were to be obtained. He differed from most people in their preference for high manganese, to obtain good wearing properties. A specimen of high manganese iron which he exhibited showed the spiky nature of the crystals produced. These crystals were very hard, would not spread under work, and broke off, forming grit, which gave bad wearing properties. He did not agree with the use of a drop test consisting of dropping a ball through a hole in a plate. In the impact test suggested in the Paper a low test number was obtained at the start, and, by increasing the differences in drop with each blow, there was eventually obtained a reliable figure. With regard to the question of the drill-test results obtained with open-grained iron with high combined carbon content, he had made that class of iron many times in the production of cylinders very much bigger than Mr. Harley was in the habit of making. With quickly-cooled cylinders, such as aeroplane or motor-car cylinders, the length of time given for the cooling was not sufficient to bring about the phenomena mentioned. Mr. Broughall had made some remarks with regard to the drill test. He (Mr. Cook) agreed that it was not a foundryman's test, but a machine-shop test, or a test against the foundry. He must say, however, that it had proved of very great use, inasmuch as while the variations in hardness of the metal obtained when the tests were first started were anything up to 40 per cent. of hardness from day to day, it had enabled this factor to be regulated to within 10 per cent. up or down of the desired standard. No doubt Keep's test would give everything that a foundryman wanted to know about his work. Personally, he had used it for many years, and could support everything that Mr. Broughall had said about it. Mr. Harley had referred to the K bars. They were made from the same ladle of metal, the first being cast from the metal at the right temperature as it came from the cupola, and the others with interval of times in between. He (Mr. Cook) had tried to make it quite clear in the Paper that the test suggested was only applicable to low-silicon low-carbon irons, which were very different from the composition of the iron Mr. Harley had tried. With regard to phosphorus, Mr. Harley had differed from his remarks with regard to 1 per cent. of phosphorus. He stated very definitely in the Paper that the elements in the proportion shown were for bars cast 1¼ in. diameter, not for motor car cylinders. It was obviously necessary to vary all the elements given when making castings thicker or thinner than the dimensions stated. It was found that with the big cylinder shown, using 0.4 per cent. of phosphorus, cracks took place, but when this was increased to 1 per cent. the trouble was got rid of.

The Cost of Grinding Castings.

Mr. Wallace T. Montague, in his book entitled "Grits and Grinds," published by the Norton Company, Worcester, Mass., U.S.A., has some instructive remarks on the question of free-cutting *v.* long-life grinding wheels, of which the following is an abstract:—

There is a commendable tendency for large foundries to use softer wheels for their rough-grinding work than were formerly employed. This is especially to be noticed among concerns that grind large quantities of duplicates under the piece-work system of payment. Low first cost and long life are no longer the chief requisites that interest the purchaser of grinding wheels. It is now recognised that rapid cutting wheels requiring infrequent dressing are the most economical in the long run.

With grinding coming more into use, it will pay the consumer to look carefully into his grinding costs and check them from time to time, in order to be sure that his final abrasive cost per unit of output, taking wheel cost, labour, power and maintenance cost into consideration, is reduced to a minimum. Where there is a constant duplication of work in large foundries and the piece-work system is employed, there is a very simple but serviceable method for computing the relative efficiency of various kinds of grinding wheels. The workman's earnings on a given job per unit cost of wheel may be considered under these circumstances a very fair means of determining the actual value being received for the money invested. These earnings should be averaged from the individual earnings of each man employed on the same class of work and the data collected for a sufficiently long period to eliminate the personal factor and to reduce the chances of error to a minimum.

For instance, the average earnings of several men grinding a certain class of steel castings might be £1 16s. per man in a given time and each might average to wear out completely a grinding wheel costing £1 4s., which means that for every pound of cost of wheel the workman earns £1 10s.

It should now be clearly established by the shop manager whether or not he is using the most economical grinding wheel for the work at hand. Comparative tests should be conducted on wheels of slightly harder or softer grades, perhaps of coarser or finer grits, until the results plainly indicate that the most efficient wheel has been found; that is, the one that earns the most for the workman per unit cost of wheel to the manufacturer. When this condition exists one may be sure that (1) the wheel is a rapid cutter, yielding high production; (2) that wasteful dressing away of the wheel is reduced to a minimum; (3) that the power, labour and general maintenance cost are lower than they would be otherwise. In other words, one may be sure that one has reduced the abrasive cost per unit of production to its lowest value. When this point is reached, the manufacturer has a fair knowledge of the abrasive consumption necessary to get his work done, and can readily detect inefficient work or a falling off in the quality of the wheels.

Grinding Ploughs Economically.—An interesting method is used in the plough industry for checking the abrasive cost, which may be applied to other industries.

Suppose a 30-in. by 4-in. grinding wheel costs the manufacturer $51.30 (£10 5s.). When it is 26 in. in diameter it is only worth $39.30 (£7 17s.), or $12 (£2 8s.) worth of abrasive has been used. If the operator's earnings during that time were $15.60 (£3 2s. 6d.), the earnings per dollar cost of wheel were $1.30 (5s. 3d.), whereas the minimum requirement might be $1.20 (4s. 10d.). To encourage workmen to use their wheels economically, a bonus is often paid for all earnings in excess of $20 (say £4) in using a wheel down from 30 in. to 26 in. in diameter.

At 26 in. diameter the wheel is removed and placed on a machine with higher spindle speed, and the wheel worn down to 20 in. diameter. At 20 in. diameter a similar change is made to another machine with still higher spindle speed. The average wheel speed in all cases should be about 5,000 surface feet per minute. Bonuses are paid for excess earnings in all these stages and thus the maximum efficiency of use is bound to be attained.

Earnings per unit cost of wheel should not drop below a certain carefully determined figure. If they do, the foreman knows that the wheel is either too hard and has to be dressed too frequently, or that the wheel is too soft and wears away too fast, or even that the wheel is satisfactory, but is being wasted away by unnecessary dressing at the hand of an unskilled or careless workman.

Still a third method is used occasionally on duplicate work and with excellent results. The following records are kept: Date, pieces ground, weight in pounds, hours of grinding, earnings, wheel loss on diameter and cubic inches of abrasive consumed. A better check is obtained where the piece-work system is employed. These figures enable the manufacturer to calculate for every ton of castings ground the amount of abrasive consumed, the cost of the abrasive, the average earnings per hour for each man, or general average for all and their average earnings.

If a given grain and grade of wheel grinds an average of a ton of castings with an abrasive consumption of 35 cubic inches, abrasive cost of 1s. 10½d. and man's earnings of 1s. 2d. per hour, and another grain and grade of wheel grinds an average of a ton of the same castings with an abrasive consumption of 25 cubic inches, an abrasive cost of 1s. 4d., and man's earnings of 1s. 2d., it is very apparent which wheel should be chosen for the work. If, on the other hand, in the second case the man's earnings per hour had fallen off materially, it would have clearly indicated that the second wheel was too hard.

Dressing the Wheel.—A grinding wheel should be dressed when its face is worn too smooth, or the wheel is out of round, or worn uneven on the face. By far the most frequent use of the dresser is to sharpen the wheel face, and this merely requires the removal of about 1/32-in.—just the skin.

An 18 by 2 by 1½-in. wheel might cost a concern £1 12s., and could be used down to 8 in. diameter. This would leave about 400 cubic inches of abrasive available for work, at a cost of about 1d. per cubic inch. Suppose when this wheel is 16 in. in diameter it should require sharpening and the workman used his dresser carelessly, removing ½-inch from the diameter of the wheel. This represents over 6½ cubic inches of abrasive valued at about 6½d., and most of it is absolutely wasted.

Power Consumption.—The question of power consumption receives little attention at present. It requires approximately 5 h.p. to drive a grinding machine with a 24 by 2½-in. rough grinding wheel of the correct working grain and grade. It might require 5¼ h.p. to drive a slow wearing wheel on the same work. The freer cutting wheel will cut much faster than the hard wheel, probably from 10 to 25 per cent. faster, which means that the horsepower or kilowatt-hours required to do a given work with the freer cutting wheel will be much lower than on the harder wheel.

Power costs money, and there is no question but that the difference in the power consumption of a grinding plant using free cutting wheels and one using wheels bought chiefly on long-life specifications, will amount to several scores of pounds sterling per year.

Casting Chilled Rolls.

By A. R. B.

The question has recently been raised as to the method of casting small chilled rolls or cylinders about 9 in. long by 5 in. diameter, with ⅝-in. thick walls, the ends and bore of interior flange to be machined.

In the first place, as to material of which the chillers should be made, this should, undoubtedly, be what is known in foundry circles as "semi-steel" or cast iron with steel added. According to the writer's experience the chillers that give the longest life are cast from a mixture of about 3 cwts. steel scrap, 7 cwts. hematite No. 3, 10 cwts. of clean shop scrap, preferably scrap from a previous cast of the same mixture. As to what thickness the chiller should be, this depends entirely on how long the chiller is expected to last, also what depth of chiller is wanted on the casting. The practice adopted will vary according to whether denseness only is required on the outside or the cylinder is required to be hard chilled and impossible to machine; also if the chilling takes place all along the surface to the ends, the outer edges of the latter will be unmachineable, grinding being the only possible way of producing a clean surface. If it is imperative that a machine cut be taken over the ends then the chiller must not be the full length.

The air in the mould must be allowed to escape very freely, or the top surface will be pitted with holes and rendered useless. If the nature of the casting allows a head, and this could be above the chill, it would take the pitting, and when cut off would leave a good casting. It is also necessary to know what work the rolls have to do, for if required for chemicals a close hard mixture would be needful, and certainly a glass-hard surface on the chilled face; but if for vegetable matter a softer surface would suffice. As an experiment the writer cast a 4½ in. bush in a chiller 9 in. long and 2½ in. thick, and put a 3 in. core in it. It was cast with a sand bottom and top part. The result was a close-grained surface, but not chilled so hard that it would be impossible to machine with a slow cut. The bore and the ends could be machined easily. The casting was broken to see what it would be like, and the above remarks are the result. The mixture of metal was an ordinary one for general work, and consisted of 4 cwt. silicious pig of about 4.5 per cent. silicon, 3 cwt. No. 3 Carron, 2 cwt. No. 3 hematite, 12 cwt. scrap (heavy machinery). This the writer considers is of no value for the general run of chilled rolls. Chilled rolls of a much larger size and heavier type are made, using a mixture of 7 cwt. Fencamp, 2 cwt. Warner C.B.R., 4 cwt. No. 5 hematite, 8 cwt. scrap from previous cast of same. This produces a very hard chilled surface, but would be too hard for a small thing like the roll under discussion. It therefore follows that something between the two mixtures would most likely be needed. Again, whoever wants to make the job most likely wants to use what brands of iron are in his hands or easily procurable.

Another point is, will any taper be allowable on the casting. If not, a split chill may be necessary to enable the casting to be removed readily. This would mean half chills, with flanges running the length of same and bolts or other means of holding together during pouring. By this it will be seen that the job is considered as being cast vertically. The metal would be best dropped from the top.

Certainly the chiller should not be the full length of the casting; otherwise if hard chilled the edges at top and bottom could not be machined. Again, if shorter than the casting, the air and gases could be directed through the sand, making up the depth at the top end.

Really the man on the spot should be the best person to decide the questions raised, but he must certainly experiment a little and not expect to drop on what is the ideal thing at once.

Zirconia as a Refractory.

A meeting promoted by the Refractory Materials Section of the Ceramic Society, and attended by manufacturers and others interested in the fireclay industry from various parts of the country, was held last month at the Leeds University. Mr. William Oates, who presided, suggested that the Society should co-operate with the Iron and Steel Institute.

In a Paper on "The Use of Zirconia as a Refractory Material," Mr. J. A. Audley (Stoke-on-Trent) remarked that in Germany patents had been taken out for the use of zirconia in a variety of ways. As a refractory it was applied to lining muffles, retorts, and tubes, and to crucibles in which quartz was to be fused to prepare quartz glass. It had been placed on record that a zirconia-lined hearth of an open-hearth furnace in a steelworks in Germany, after four months' continuous working at a high temperature, was still in good condition and capable of serving at least four months longer before renewal would be necessary. Calculations based on some tests showed in actual maintenance cost a saving of over 50 per cent. in favour of zirconia lining as compared with the refractory lining ordinarily used. In the calculations no allowance was made for increased production and higher efficiency. Another interesting application of zirconia was in the manufacture of ferro-zirconium, which had been successfully employed in Germany for producing zirconium steel for armour plates, armour-piercing projectiles, bullet-proof steel, etc. Zirconium steels were particularly hard, and it was affirmed that one-inch zirconium steel was equal to three-inch armour plate of the best German steel. Before the war there was practically a German monopoly of the raw zirconia ore, which was mainly dealt with under German patents. This was now, of course, available for this and other countries, provided that they could find a means for transferring it.

Case-Hardening.

Before the members of the Rotherham Technical Institute Engineering Society recently Dr. T. Baker, D.Sc. (research expert for Messrs. Steel, Peech & Tozer, Limited), explained that case-hardening was supposed to have been known to the Chinese in the eighth century. A Benedictine monk wrote a book on the production of files by coating file forgings of wrought iron with a paste of horn meal and salt, heating them over a breeze fire until the salt melted, and then quenching them in water. It was not, however, in the production of files that the process found its most useful application to-day, but in the production of machine parts which had to withstand excessive wear and at the same time possess a marked degree of toughness and resistance to shock, such as gear wheels, cams, bearings, ball races, and also in the manufacture of reamers, taps, gauges and other similar articles.

There were two main objects to be considered, namely, the selection of a suitable steel and the choice of a composition. There were one or two points of great importance to be taken into consideration in the selection of a suitable steel. In the first place it must machine readily and finish with a good surface, especially in those instances where the article could not afterwards be ground to the finished shape, but must be finished in a cutting machine before case-hardening, as in the case of gears. Secondly, there was the question as to whether the core must be fibrous and capable of withstanding shocks and a certain amount of bending, or whether a finely crystalline structure in the core would serve the purpose, as in the case of ball races. For the production of small articles (which required a fibrous core) a very soft steel was employed, which approached wrought iron in composition, viz., C about 0.1 per cent. and manganese about 0.40 per cent. This material, however, possessed the disadvantage that it was not at all easy to machine so as to obtain a good surface. Bars from the same delivery might vary considerably in this respect, and it was quite possible if the bars were normalised (i.e., heated to about 900 deg. C. and air-cooled) before machining fewer wasters would be produced and much time saved in machining. Further, this type of steel sometimes contained slag enclosures, which were often detrimental to a good case. This class of steel could also be used for the production of large articles, but the use of one containing more carbon and manganese was advantageous, since it was much more likely to machine freely, to be free from slag enclosures, and at the same time give a core which possessed greater resistance to crushing. It had to be remembered, however, that the harder the steel became—i.e., the more carbon and manganese it contained—the more sensitive it was to the quenching operation which followed the casing operation; and in small articles a high-carbon steel might lead to a brittle core instead of a tough one, whilst in a larger object it would probably have little or no detrimental effect. If still tougher cores are required, nickel steels containing 2 to 3 per cent. nickel were employed. As regarded treatment, they did not differ from ordinary steels of the same carbon content. Under certain circumstances steels containing 4 to 6 per cent. nickel were employed. These behaved in a manner totally different from the plain-carbon and low-nickel steels, and since they did not require quenching after casing in order to produce a hard surface, they were used for the manufacture of articles of intricate design which might be distorted by quenching.

In the selection of suitable case-hardening compounds there was a large choice. They might be divided into three great classes—liquid, gaseous and solid. As the liquid cements mostly contained potassium cyanide, the greatest care must be exercised to avoid poisoning. Gaseous cements had come into vogue during the past few years. These consisted of the vapours obtained from heating various oils, which were led under pressure into a closed heated chamber containing the articles to be case-hardened. This method was easily controlled, as both the quantity and the pressure of the hydrocarbon vapours could be regulated. Solid cements were, however, the most largely used at the present time. They consisted chiefly of carbon in its various forms, together with other substances such as salt, sawdust, carbonate of soda, barium and calcium carbonates and many other substances which in all probability had little or no effect on the process. The main consideration was that they should contain the requisite elements and at the same time be open in structure, so that the gases produced by heating them could easily come in contact with the steel undergoing treatment. The direct action of carbon in producing cementation in the practical sense of the word was *nil*, but when mixed with air and some other substance which would produce CO, it became one of the most active of agents. If a piece of steel was packed round in a box with pine wood charcoal and heated to a temperature of about 950 deg. C., sufficient air was contained in the charcoal to yield enough carbon monoxide to produce a marked cementation of the steel, but it was preferable to mix the charcoal with some substance such as barium carbonate, which at the temperature of cementation gave off carbon dioxide. This latter reacted with the charcoal, producing carbon monoxide, and in that way brought about cementation. A mixture very largely used at the present time was one consisting of forty parts by weight of barium carbonate and sixty parts by weight of charcoal. Such a mixture had the advantage of being easily revivified by simple exposure to the atmosphere. To understand the subsequent treatment of the cemented steels it was necessary to review the structural alterations in a piece of steel during heating and cooling.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Alexander, H., Vint, W. T., and Imbery, A. Processes for heating, melting, and annealing metals by electricity. 2,378. February 27.
Ashcroft, E. A. Manufacture and use of silicon chloride and removal of silica from fused melts. 2,418. February 19.
Boving, J. O. Electric furnaces. 2,807. February 26.
Hall, I. Means for melting metals, etc. 2,314. February 16.
Hall, I. Die-casting, etc., machines. 2,465. February 20.
Hall, I. Furnaces, heating-apparatus, etc. 2,483. February 20.
Hall, I. Furnaces. 2,484. February 20.
Hall, I. Means for melting and casting metals, etc. 2,573. February 23.
Head, Wrightson, & Company, Wrightson, T. G., and Ringquist, J. M. Hoists for charging blast furnaces, etc. 2,273. February 15.
Head, Wrightson, & Company, Wrightson, T. G., and Ringquist, J. M. Blast furnaces, etc. 2,274. February 15.
Head, Wrightson, & Company, Wrightson, T. G., and Ringquist, J. M. Means for manipulating skips or buckets. 2,275. February 15.
Keller, C. A. Manufacture of steel. 2,391. February 17.
Shanks, J. K. Melting-furnaces. 2,400. February 19.
Williams, E. Fire-brick linings, arches, etc., for furnaces, etc. 2,634. February 22.

Institute of Metals.

The annual meeting of the Institute of Metals was held on Wednesday and Thursday, March 21 and 22 at Burlington House, Piccadilly, London.

According to the Council's report there were on the roll of the Institute on December 31 last 4 honorary members, 648 ordinary members and 8 students, making a total of 660. This total has been arrived at after the removal from the register of the names of 18 members of enemy nationality, leaving a net increase of 20 during the past year. In the autumn of 1916 a conference was held of the Presidents and Secretaries of the Iron and Steel Institute, the Institution of Mining and Metallurgy, the Institution of Mining Engineers, and of the Institute of Metals, with a view to discussing the possibility of the setting up of a joint building for the four societies. The proposal, approved in principle by the Council, is now receiving detailed consideration, and the various institutions are arranging not to renew their existing leases beyond a short period. The reconstitution of the old Corrosion Committee, decided upon by the Council in 1916, has been effected during the past year. Its members are now appointed as to one-half by the Council and as to the other half by certain Government Departments, public bodies, societies, and institutions interested in the subject of the corrosion of non-ferrous metals. Professor Carpenter has been appointed chairman. Following the reconstruction of the Committee there was received, through the Department of Scientific and Industrial Research, a grant of £325 towards expenses for the six months ended September 30, 1916. The grant was conditional upon the appointment of a salaried investigator, who would devote his whole time to carrying on the corrosion research investigations at the Committee's Research Station in the University of Liverpool. The Committee secured the services of Dr. G. D. Bengough as investigator, and appointed Dr. O. F. Hudson, of the University of Birmingham, as assistant investigator. On indication being received that the Department of Scientific and Industrial Research would be prepared to increase the grant to £900 per annum as from October 1, 1917, it was decided to transfer the laboratory to the Metallurgical Department of the Royal School of Mines.

A number of papers were read and discussed, among them being several dealing with the melting of metals; some of these are dealt with in this issue.

Non-Ferrous Notes.

Dutch Metal.—This is the name given to brasses of 80 to 85 per cent. copper and 15 to 20 per cent. zinc, which can be hammered out into very thin leaves. The name signifies that this metal is used for Dutch metal guilding.

Purifying Alloys.—A method of purifying alloys was evolved a few years ago by Bryant & Ivinson, in which the metal to be purified is passed, while in the melted state, through a sieve, and allowed to fall into a suitable flux. The fine state of division was claimed to result in complete purification of the metal or alloy. As an example, for the purification of zinc the metal is melted and passed through the sieve and allowed to drop into a solution of phosphorus in oil and a zinc chloride solution, the oil floating on the latter solution. Greater freedom from oxide and a very much better quality in the brass made from this zinc was claimed.

White-Brass or Babbitt-Metal?—A method of distinguishing between white brass and Babbitt-metal was described by H. D. Gehret in "The Brass World." The Parson's white-brass in question contained the following :—Tin, 68.0 per cent.; zinc, 30.0 per cent.; copper, 2.0 per cent. The Babbitt-metal had the following composition :—Tin, 92.6 per cent.; antimony, 3.7 per cent.; copper, 3.7 per cent. It was found that if a drop of strong nitric acid were placed on the Babbitt-metal a very dark-coloured ring was immediately formed around the edge of acid. The treatment of the Parson's white brass by the same acid caused merely a slight discoloration.

Annealing of Nickel Silver.—The second part of this paper was presented before the Institute of Metals at the last meeting by F. C. Thompson, D.Met., B.Sc. (Sheffield). The Paper dealt with the influence of the duration of annealing at a temperature of 800 deg. C. on the hardness and ductility of nickel silver with 10 per cent. of nickel. A period of five hours yields the material in its best condition. It is also shown that the alloy deoxidised with cupro-manganese is superior to one not so treated, and that nickel silver cast from clay pots is more ductile than that from plumbago crucibles. Dealing with the influence of the rate of cooling from the annealing temperature on the properties of the nickel silvers, it is shown that both very slow and very rapid cooling yield soft, ductile material, while air-cooling gives a hard, less ductile alloy.

Tin Pest.—Metallic tin when exposed to a very low temperature becomes brittle. Prof. Cohen investigated the subject and found that all metallic tin is subject to decay or disintegration when exposed to a low temperature and the purer it is, the more readily it decays. This decay is, in reality, a crumbling to a grey, granular mass. Metallic tin exposed to a low temperature will gradually change to the allotropic or grey form of tin in the shape of powder. Massive tin will become granular, and sheet metal may become perforated by the formation of the "tin-pest." The lower the temperature the more rapid is the decay of the tin. It should be kept above 18 deg. C., as this seems to be the point of transition. The granular, grey tin resulting from the decay of white tin is only an allotropic form of tin, as it may be changed to the white variety by simple melting. When the tin decays to the grey powder it increases in volume. The decay may be brought about or hastened by infection. If white tin be brought in contact with a trace of the grey powder, resulting from the decay of another mass, the decay takes place at this point and gradually increases in volume.

White, Non-Corrosive Iron-Nickel-Copper Alloy.—A white, non-corrosive and malleable alloy of iron, nickel and copper patented by Clamer may be rolled, drawn, or cast in sand. It has a whitish colour, and can be made in the following range of percentages :—Iron, 30 per cent. to 70 per cent.; nickel, 25 per cent. to 50 per cent.; copper, 5 per cent. to 20 per cent. Pure copper and iron will alloy in all proportions and form a homogeneous mixture; but when carbon is present, as it is in steel or cast iron, the two metals do not alloy well and hard nodules separate, depending upon the quantity of carbon. If, however, carbon is present, then the tensile strength of the alloy is increased, but the quantity should not exceed 0.2 per cent. in order to have the best conditions. A typical mixture is :—Iron, 65 per cent.; nickel, 25 per cent.; copper, 10 per cent.; carbon, 0.2 per cent. The physical properties of this were stated by Clamer to be :—Tensile strength, 96,100 lbs. sq. in.; elastic limit, 51,750 lbs. sq. in.; elongation in 2 in., 42 per cent.; reduction in area, 53.7 per cent. To make the alloy, the metals are melted so that carbon is kept low and a small amount of manganese or magnesium added for deoxidising purposes.

QUERY.—Chrome Bronze.—I should be pleased if any reader could give me information concerning Chrome Bronze, by Hospitalier; whether it is used in casting copper. If so, in what proportion?—"R. W. W."

Trade Talk.

THE offices of the Institute of Metals are now at 36, Victoria Street, Westminster, S.W., 1.

THE offices of the Thermo Electric Ore Reduction Corporation, Limited, have been removed to 244, High Holborn, London, W.C.

MR. A. E. OWEN has purchased the business of H. M. Joel & Company, steel and file manufacturers, Wellmeadow Works, Sheffield.

THE WELLINGTON FOUNDRIES, LIMITED, are being wound up voluntarily, with Mr. W. R. Thomas, 59, Wind Street, Swansea, as liquidator.

MESSRS. SCHWARTE & HAMMER, metal merchants and agents, 3, East India Avenue, London, E.C., will in future trade as Hammer & Company.

THOMAS SCOTT & COMPANY (LONDON), LIMITED, iron and steel merchants, etc., have removed to 2 and 4, Leroy Street, Old Kent Road, London, S.E.

THE IMPROVED CASTING SYNDICATE, LIMITED, is being wound up voluntarily, with Mr. T. G. Haward, 6, Broad Street Place, E.C. 2, as liquidator.

MR. JAS. PORTEOUS SCOTT, iron warrant broker, whose address was formerly 125, Buchanan Street, Glasgow, is now to be found at 12, Bute Mansions, Glasgow, W.

A RECEIVING order has been made in connection with the affairs of Mr. A. P. Collins, metal merchant, lately carrying on business at New Canal Street, and 116, Snow Hill, Birmingham.

MESSRS. NATHAN & ALLEN, the Wardle Engineering Company, Limited, and Parmiter, Hope & Sugden, Limited, have removed their London offices to 25, Victoria Street, London, S.W.

FIFTY-FOUR additional establishments have been declared controlled establishments. The total number of controlled establishments under the Munitions of War Acts, 1915 and 1916, is now 4,770.

MESSRS. C. M. SANDERS AND F. M. SANDERS, carrying on business as metal brokers and agents, at 139, Fenchurch Street, London, E.C., under the style of Sanders Bros. & Company, have dissolved partnership.

THE GRIFFIN IRONWORKS & ALBION FOUNDRY, LIMITED, are being wound up voluntarily, with Mr. J. W. Blackham, 180, Corporation Street, Birmingham, as liquidator.

MESSRS. JOHN GILLOTT & SONS, of the Lancaster Works, Barnsley, are installing a 10-cwt. Greaves-Etchells electric furnace in their steel foundry. This is designed to supplement, not to supersede the crucible plant.

WILLIAM JOHNSON & SONS (LEEDS), LIMITED, are extending the shops and building new offices at their Armley Road works. The extension of the works has become necessary owing to the increased demand for spelter machinery.

MESSRS J. SMAIL and J. MUNDELL, brass founders and metal workers, 28-32, Lower Moss Lane, Hulme, Manchester, trading as the Knowsley Cast Metal Company, have dissolved partnership.

MESSRS. J. FLETCHER, F. H. FLETCHER, and E. SHAW, machine tool makers, Green Mount Engineering Works, Hanson Lane, Halifax, trading under the style of Fletcher Brothers, have dissolved partnership.

AFTER having been closed down for over a year, the Tudhoe Blastfurnaces, Spennymoor, were again put into blast last month, the South Durham Steel and Iron Company, Limited, Stockton, having taken a lease of the works from the Weardale Steel, Coal and Coke Company, Limited.

IT is proposed that the 100,000 unissued preference shares of the Vulcan Foundry, Limited, shall be converted into ordinary shares, and that £37,086 standing to the credit of the revenue reserve be distributed as a bonus. The directors will issue 37,086 of the unissued ordinary shares credited as fully paid to the holders of the ordinary shares pro rata.

IT was reported some time ago that the Italian Government contemplated appointing a committee in London charged with carrying through pig-iron transactions in this country. Scottish makers and merchants, however, protested, with the result that no committee is to be nominated, and trade between Italian and Scotch houses it to be effected direct.

THE two partners of James White & Company, Canal Foundry, Lambhill, Glasgow, appeared at the Glasgow Bankruptcy Court on March 8 for public examination under their sequestration. Mr. J. White stated that he began business in 1912 with £130 capital, and carried on for a period of eighteen months, when he assumed Mr. T. Aucott as a partner. The statement of affairs showed a deficiency of £3,500, which was partly due to the rise in the price of materials. The examination was closed.

IT will be remembered that in August last the debenture holders of the Electro-Flex Steel Company, Limited, appointed a receiver and manager and the company went into liquidation. The property has since then been sold by the receiver to a new company called the Tyne Electric Steel Foundries, Limited. Under the terms of the sale the debentures in the former company will be paid off and reinvested as preference shares of equivalent amount in the new company.

AN ORDER-IN-COUNCIL published last month provides that in Defence of the Realm Regulation 41A—which lays upon employers the duty of keeping a register of all male employés between the ages of eighteen and forty-one—the words "of sixteen years or over" shall be substituted for the words "between the ages of eighteen and forty-one" wherever they occur, except in paragraph (iii) of sub-section (3), where the words "all other male persons of sixteen years or over" shall be substituted for the words "male persons not being between the ages of eighteen and forty-one." The Director-General of National Service is to be furnished with a copy of the register if and when required.

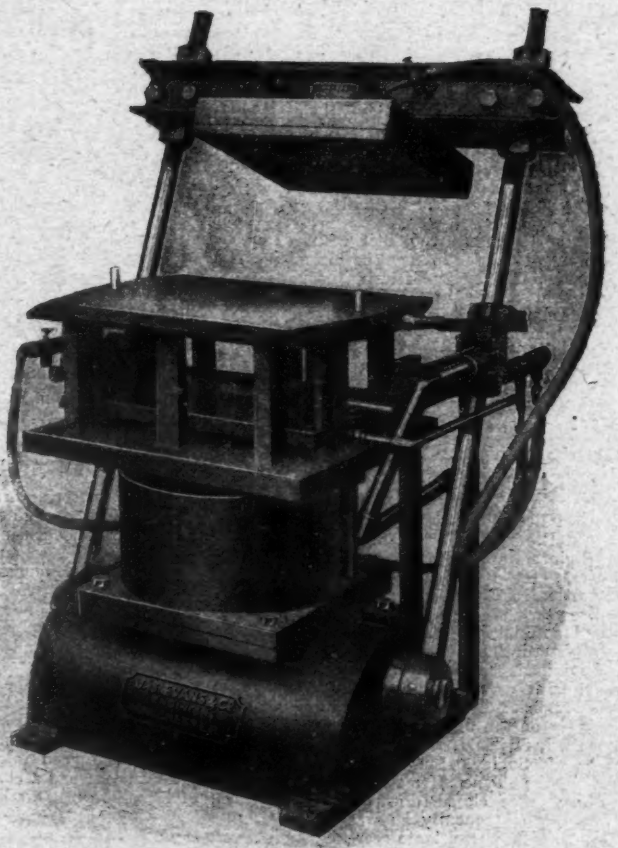
ESTIMATES for 1917-18 in respect of education, science, and art amount to £21,412,175, a net increase on the sum voted for 1916-17 of £764,787. The rise is accounted for almost entirely by a new grant of £1,000,000 in aid of scientific and industrial research. This sum will be paid to the account of the Imperial Trust for the encouragement of scientific and industrial research, and grants will be made by the directions of the Privy Council Committee over an agreed period to approved trade associations. Provision is also made for the distribution by the same committee, on the recommendation of the Advisory Council on scientific and industrial research, of grants totalling £24,000 in aid of investigations carried out by learned and scientific societies, and £6,000 to students and others engaged in research.

DAVID BROWN & SONS (HUDDERSFIELD), LIMITED, are engaged upon very considerable and important extensions at their Park Works, Huddersfield. The pressing requirements of the country have naturally led to an abnormal increase in demand for cut gears, and as the capacity of the Park Works was taxed to its utmost to meet the demand on ordinary commercial account in normal times, the present extensions were a vital necessity. They comprise the erection of a new machine shop 308 ft. long by 45 ft. wide by 30 ft. high to the crane runway. This building has been finished and much of the machinery is installed. The floor is served by a 20-ton crane. The equipment includes gear cutting machines suitable for generating gears for transmitting up to 15,000 h.p. On the one side of the machine shop is a new foundry nearing completion, similar in size to the machine shop, and castings up to 20 tons in weight will be produced. On the opposite side of the machine shop a third bay of similar dimensions is in course of building for service as an erecting shop. Immediately across the yard and in close proximity to the foundry a new pattern shop is in course of construction. This, built of ferro-concrete throughout, will be a building of three storeys, 145 ft. 6 in. by 55 ft. 6 in. by 42 ft. 6 in. high. It will thus be seen that when completed the extensions will be virtually a self-contained new works.

MOULDING MACHINES

OF EVERY DESCRIPTION.

Pneumatic, Hydraulic, Jar Ramming, & Hand Power.



JAMES EVANS & CO., BRITANNIA WORKS,

BLACKFRIARS, **MANCHESTER.**

Deaths.

Mr. James Frew, of the late firm of John Frew & Company, ironfounders, Hamilton died on March 19.

The death is announced of Mr. A. H. Mould, chairman of Alfred H. Mould & Sons, Limited, ironfounders, Walsall.

The death took place recently of Mr. Joseph Ardron, manager of the file department of Sanderson, Bros. & Newbould, Limited.

The death took place recently of Mr. M. Morris, of J. & M. Morris, Limited, ironfounders, Welshpool, at the age of 71 years.

The death has occurred at Crosby Cote, Northallerton, of Mr. Albert de Lande Long, founder with Mr. A. J. Dorman, of the firm of Dorman, Long & Company, Limited, Middlesbrough.

Mr. George Pyper, managing director of Lawson, Turnbull & Company, Limited, metal merchants, Aberdeen, died on March 11, aged 36 years. He succeeded his father as managing director in 1909.

Mr. Patrick Fraser, of the firm of Douglas Fraser & Sons, Limited, engineers, Arbroath, died last month, aged 63 years. The deceased was widely known over a large area in Scotland, and was a Justice of the Peace.

The death has taken place at Swansea of Mr. F. S. Parker, metal merchant, for many years a regular attendant at the Swansea Metal Exchange. The deceased, who was 66 years of age, had been ill for a considerable time.

Flight-Lieut. Gordon Daglish, who met with a fatal accident while flying last month, was the second son of Mr. J. Daglish, of the North-Eastern Marine Engineering Company, and was in the employ of that firm prior to joining the Army in 1914.

Mr. R. Alexander, iron merchant, Aberdeen, died on the 15th ult., aged 68 years. The deceased started business early in life as an iron merchant in Broad Street, Aberdeen, but about eighteen years ago removed to 129, Park Street, Aberdeen.

The death occurred on March 1, at his residence, The Uplands, Selly Hill, of Mr. C. Winn. The deceased, who in a few days would have completed his 88th year, was the head of the firm of Charles Winn & Company, engineers, Birmingham.

Sir Benjamin Chapman Browne, the well-known engineer, and chairman of R. & W. Hawthorn, Leslie & Company, Limited, engineers and shipbuilders, died at Newcastle, on March 1. Sir Benjamin, who was 78, was Mayor of Newcastle from 1885 to 1887, and was knighted in the Jubilee year.

The death occurred at Lincoln, last month, in his 80th year, of Col. Edward Snow Mason, an Indian Mutiny veteran, who joined the Army in 1854. Col. Mason was connected with several public companies, was a director of Clayton & Shuttleworth, Limited, and up to quite recently on the directorate of Joseph Rodgers & Sons, Limited, Sheffield.

Mr. R. A. Lewis, of Sugley House, Lemington, who was manager of the Tyne Hematite Works, Lemington, before they were closed down and dismantled, died recently. Subsequently he was transferred to the Newburn Works as private secretary to Mr. J. W. Spencer, and also foreign correspondent to the firm. He was 70 years of age.

The death is announced of M. Adrien Badin, president of the Aluminium Francais and deputy-manager of the Produits Chimiques d'Alais, at the age of 44 years. The deceased was exceedingly well known in the aluminium industry, and spent his life in developing French resources. He also established plants in America, Norway, Italy and Russia.

Second Lieutenant C. D. McCourt, London Regiment, who has been killed in action, was at one time chief chemist to the Morgan Crucible Company, Limited, which post he resigned in order to collaborate with Professor W. A. Bone on the industrial applications of incandescent surface combustion, which resulted in the "Bonecourt" system of surface combustion.

Major James Forbes Jones, managing director of Jones & Campbell, Limited, ironfounders, Torwood Foundry, Larbert, has died of appendicitis in hospital in France. He was 37 years of age, and for a long number of years was an enthusiastic member first of the volunteers and latterly of the Territorial Forces. At the time of the outbreak of war he held the rank of captain in the local Territorial Battalion of the Argyll and Sutherland Highlanders. He went to France in April, 1915, and was mentioned in despatches in January, 1916.

The death has occurred at Grangethorpe, Rusholme, Manchester, of Mr. H. H. Smith-Carington, at the age of 66 years. The deceased, after training as an engineer, was appointed assistant secretary to Sir Joseph Whitworth & Company, Limited, in 1874, and four years later became secretary to the company, being made a director in 1887. On the amalgamation of his company with the Elswick works of Sir W. G. Armstrong & Company, he became a director of the joint concerns.

The death is announced of Mr. C. H. Treglown, of Birmingham, at the age of 81. A Cornishman by birth, he began life in the engine shops of the old West Cornwall Railway, and afterwards entered the employ of the Midland Railway Company at Derby. In 1860 he returned to Cornwall in a consulting capacity to a number of Cornish tin mines, and in 1874 he went to Birmingham to take a position with the firm of Messrs. Tangye Brothers.

Mr. James Forrest, who has had a life-long connection with the Institution of Civil Engineers, has died at the advanced age of 91 years. He first became connected with the Institution in 1842 through Mr. Charles Manby, the then secretary, under whom he received his professional training, and when the latter retired Mr. Forrest became acting secretary, and afterwards secretary, a post he continued to fill till 1896, when through ill-health he had to retire, and was appointed hon. secretary.

Mr. H. H. Murray died recently at his residence, Hastings Lodge, Hartlepool, at the age of 76 years. He was for over 60 years associated with the Richardson family. Mr Murray commenced his business career in 1854 in the fitting shop of the late Mr. Thos. Richardson, father of the late Sir Thos. Richardson, and founder of the engineering firm of Thos. Richardson & Sons. He was in the engineering works of that firm for over 40 years, and continued his services as secretary to Richardsons, Westgarth & Company, Limited. Some years ago he relinquished the secretarial work.

Col. F. W. Tannett Walker died last month, at Leeds, at the age of 56. A little over a year ago he was gazetted temporary Lieut.-Colonel in the Royal Engineers (Regulars), and went to France. The younger of the two sons of the late Mr. Benjamin Walker, one of the founders of the engineering firm of Messrs. Tannett, Walker & Company, of Hunslet, Col. Walker and his brother, on the death of their father, became sole owners of the business. Some years ago it was turned into a limited liability company. The concern had a chequered career, and in the spring of 1913 the works were closed.

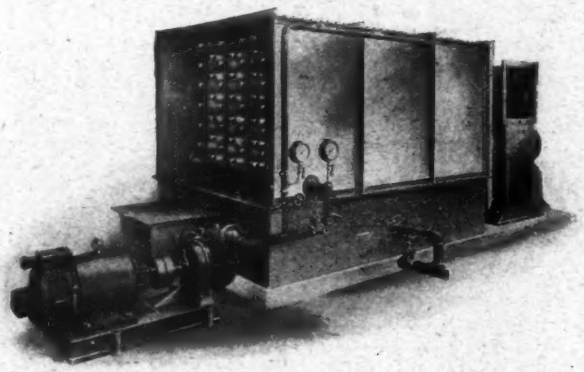
Legal.

Delta Metal Company v. Meier-Mattes.

The Delta Metal Company, Limited, applied in the Chancery Division recently for an injunction to restrain C. Meier-Mattes & Company, from in any manner representing that they were the agents for, or otherwise connected with, the plaintiffs, by misstating the name of any foreign company for whom they acted. The defendants were the London agents of the Delta Company, Schweizerische Präzisionsschraubenfabrik, and altered the title of the Pelta Company, Switzerland, to the Swiss Delta Company. The plaintiffs desired the defendants to use the full name of the Swiss company, and terms were arranged upon this basis.

SIROCCO ... TRADE ... MARK ...

Air Washers



CLEAN AIR

For

Air Compressors

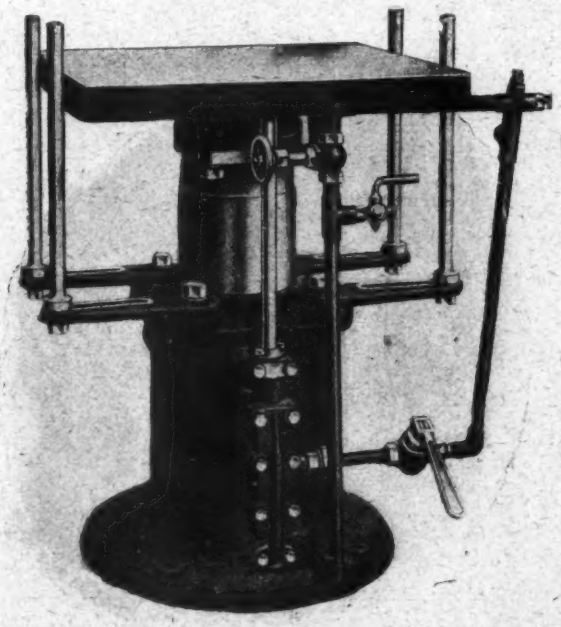
These Washers ensure clean valves and cylinders and the elimination of grit troubles and their attendant expenses.

See Publication No. 1013 K.

DAVIDSON & CO., LD.

Sirocco Works,

:: BELFAST. ::



"BRITANNIA"

JAR RAM MOULDING MACHINE

(Daimler and Wardles Patent),

fitted with

SELF-CONTAINED LIFTING APPARATUS

Makers:

BRITANNIA FOUNDRY CO.,

Coventry.

London Agents: MURPHY, STEDMAN & CO., 180, GRAY'S INN ROAD, W.C.

New Companies.

V. Goulding & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of metal manufacturers.

A. T. Evans & Company, Limited.—Capital £5,000, in £1 shares, to carry on the business of metal manufacturers.

Appliances, Limited.—Capital £1,000 in £1 shares, to carry on the business of engineers, brass and iron-founders, etc.

Renshaw Engineering Works, Limited.—Capital £5,000 in £1 shares. Registered office: 27, Chatham Road, Battersea, S.W.

British Marine Engineering Company, Limited. — Capital £30,000 in £1 shares. Registered office:—71, Finsbury Pavement, E.C.

Wright's Havelock Foundry Company, Limited.—Capital £6,000 in £1 shares. Registered office:—Havelock Street, Leicester.

Southport Engineering Company, Limited.—Capital £6,000 in £1 shares. Registered office:—Halsalls Yard, King Street, Southport.

Midland Refractories Company, Limited. — Capital £15,000 in £1 shares. Registered offices:—Bull Bridge Brick Works, Ambergate, Derby.

James Phillips & Company, Limited.—Capital £10,000 in £1 shares, to carry on the business of founders. Registered office: 65, Long Acre.

E. Reader & Sons, Limited.—Capital £20,000 in £1 shares, to take over the Phœnix Works, Nottingham, and to carry on the business of engineers, etc.

Selas-Turner Company, Limited.—Capital, £20,000 in £1 shares, to carry on the business of engineers. Registered office: Priory House, Priory Street, Coventry.

T. & R. Lees, Limited. — Capital £50,000, in £1 shares, to carry on the business of engineers. Registered office:—Park Ironworks, Hollinwood, Oldham.

Grondal, Kjellin & Company (1917), Limited.—Capital £11,001 in 2s. shares, to carry on the business of metallurgists. Registered office:—20, Abchurch Lane, E.C.

Don Steel and Tool Company, Limited.—Capital £1,000 in £1 shares. The first director is A. T. Padget. Registered office:—73, Bridge Street, Sheffield.

Minchin Engineering Company, Limited.—Capital £1,000 in £1 shares. A. Minchin is the first director. Registered office: 39, Penrhyn Road, Kingston-on-Thames.

Lancaster & Company (Manchester), Limited.—Capital £10,000 in £1 shares, to carry on the business of engineers. Registered office: 27, Corporation Street, Manchester.

Gouk & Nisbet, Limited. — Capital, £5,000, in £1 shares, to carry on the business of shipbuilders and engineers. Registered office:—142, North Woodside Road, Glasgow.

J. Hackleton, Limited.—Capital £3,000 in £1 shares, to take over the business of a manufacturer of stamped brassfoundry carried on at 21, Seymour Street, Belgrave Road, Birmingham, as J. Hackleton.

Varley's Narki Metals, Limited.—Capital £1,000 in £1 shares, to take over from G. P. Varley, of St. Helens, the benefit of certain patents for the manufacture of Narki metal. G. P. Varley first sole governing director. Registered office: Atlas Street, St. Helens, Lancashire.

Samuel Rubery & Son, Limited.—Capital £10,000 in £1 shares, to take over the business of iron and steel merchants, carried on as Samuel Rubery & Son, at Blockall, Darlaston.

Walter Steuart & Company, Limited. — Capital £5,000 in £1 shares, to carry on the business of iron and steel merchants. Registered office:—113, West Regent Street, Glasgow.

Jos. Storey & Company (Metals), Limited. — Capital £4,000, in £1 shares to take over the business formerly carried on by J. S. Abram and W. J. Abram. Registered office:—4, Post Office Chambers, Newcastle-on-Tyne.

Thomas Shore & Sons, Limited.—Capital £18,000 in £1 shares, to take over the business of engineers and ironfounders carried on by J., T., W., and A. Shore, at Etruria, Stoke-on-Trent, as Thomas Shore & Sons. Registered office:—Salem Street, Etruria.

Firth-Brearley Stainless Steel Syndicate, Limited.—Capital £30,000 in £1 shares (15,000 "A" and 15,000 "B"), to carry on the business of steel, file, saw, and edge tool manufacturers, etc. The first directors are F. Best, J. W. Fawcett, H. Brearley, and J. Maddocks. The two first-named are nominated by Thomas Firth & Sons, Limited, to represent the "A" shareholders and the two last-named to represent the "B" shareholders.

Personal.

Mr. Hans Renold, of Hans Renold, Limited, has been made a J.P. for Manchester.

The late Mr. William Barraclough, of the Union Foundry, Barnsley, left £5,110 gross.

The late Mr. J. Pritchett, retired engineer, of the Denton Ironworks, Carlisle, left estate valued at £41,545.

Mr. A. Cleghorn has been nominated as president of the Institution of Engineers and Shipbuilders in Scotland.

Mr. F. J. Leathers, Mr. R. Strachan, and Mr. W. Valder have been elected managing directors of Wm. Cory & Son, Limited.

The gross value of the estate of the late Mr. W. W. Lupton, formerly managing director of Joshua Buckton & Company, Limited, is £90,484.

The gross value of the estate of the late Sir Samuel W. Royse, of Sir S. W. Royse & Company, Limited, metal and mineral merchants, Manchester, is £45,791.

The late Mr. A. K. McCosh, managing director of William Baird & Company, Limited, left personal property in the United Kingdom of the value of £818,546.

Mr. W. Mosses, general secretary of the Pattern-makers' Society, has been appointed Director of the Labour Enlistments Department of the Ministry of Munitions.

Lieutenant-Colonel H. D. Griffiths, Monmouthshire Regiment, mentioned for distinguished services, carried on the business of an iron merchant at Griffithstown before the war.

The gross value of the estate of the late Mr. James Stirling, formerly locomotive engineer of the South-Eastern Railway Company and the Glasgow and South-Western Railway, is £22,982.

The Minister of Labour has appointed the following additional members to the committee which has recently been set up in concurrence with the Ministry of Munitions and the Director-General of National Service to advise and assist in connection with the substitution and reinforcement of labour:—Admiral Sir Francis Bridgeman, G.C.B., G.C.V.O., Mr. James P. Hinchliffe, and Mr. Herbert Lockwood.

Mr. Edgar Jones, M.P., has been appointed by the Minister of Munitions as Controller of the Priority Department. A new Priority Advisory Committee, under the chairmanship of Mr. J. Wormald, consisting of Mr. Kenneth Chance, Mr. Alexander Walker, and Mr. Henry Woodall, has been appointed to advise the Controller and the Minister as to the effect of any restrictive orders of the Ministry of Munitions upon trade, with a view to causing the minimum of hardship.

Dr. W. Ripper has been appointed Vice-Chancellor of the University of Sheffield, in succession to the Right Hon. H. A. L. Fisher, Minister of Education. Professor Ripper is D. Eng., a member of the Institution of Civil Engineers, member of the Institution of Mechanical Engineers, and honorary member of the Midland Institution of Civil, Mining, and Mechanical Engineers. Mr. Douglas Vickers, who succeeds Colonel Herbert Hughes as treasurer of the University, is managing director of Vickers, Limited.

Telegrams: "Durrans, Penistone." Telephone: 21, Penistone

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.

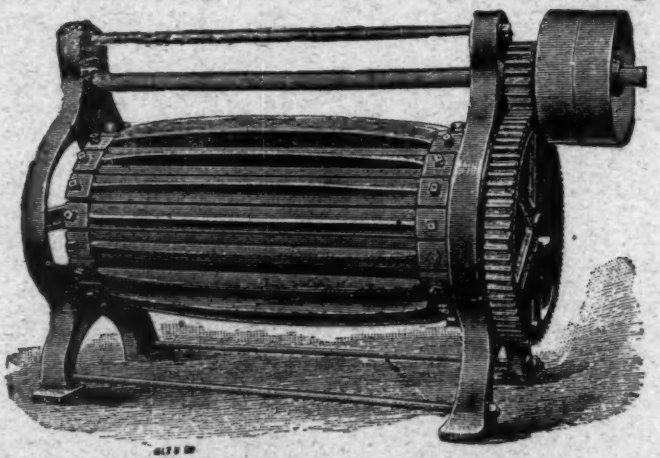
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

These maximum prices of iron, steel and coke were fixed by the Government until June 30, 1916, and thereafter until further notice. Makers may sell for delivery after June 30, on the understanding that the fixed maximum prices ruling on the 1st day of any month during the period of the contract will apply to all deliveries made during that month. This intimation must not be taken to authorise any sale or purchase or other dealing prohibited under the Defence of the Realm Regulations

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos., 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
,, ,, 0.02 ,, ...	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
,, ,, 0.02 ,, ...	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
,, ,, 0.02 ,, ...	7	0	0
Lincolnshire, basic or foundry ..	4	12	6
Cleveland, No. 1	4	11	6
,, other grades	4	7	6
Northamptonshire, forge	4	7	6
,, fdy. numbers	89/0		94/0
Derbyshire, forge	4	10	0
,, foundry numbers	92/6		96/6
Derby & Notts. basic.	4	17	6
Leicestershire & Notts., forge ..	4	10	0
,, ,, foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
,, ,, foundry	4	17	6
,, ,, basic	4	17	6
South Staffordshire—			
Part mine forge	4	15	0
,, foundry	4	17	6
Common Staffordshire ..	4	10	0
All mine forge	5	15	0
,, foundry	6	0	0
Warm air forge	7	5	0
,, foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Scotch foundry and forge—			
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works. Mers. Com. 1½%

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows :—

Finished bars, 14% Tung. 2s. 10d.

Finished bars, 18% Tung. 3s. 10d.

Per lb. basis. Extras as per authorised list. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows :—

Millings and Turnings	5d
Bar Ends	6d

Both per lb. net delivered steel makers works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome : 4/6% carbon. Basis 60%, scale 10s. per unit Per ton		—	
Ferro-chrome : 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton		—	
Ferro-chrome : 8/10% carbon. Basis 60% scale, 10s. per unit Per ton		—	
Ferro-chrome : Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton		—	
Ferro-vanadium : 33/40% Va., per lb. of Va. contained in the alloy		—	
Ferro-silicon : 45/50%. Basis 50%, 5s. scale per unit .. Per ton		—	
Ferro-titanium : 23/25%, per lb. carbonless..		—	
Ferro-molybdenum : 70/80% Mo. per pound of Mo. contained ..		—	
Ferro-phosphorus : 20/25%. Per ton		—	
Ferro-tungsten : 75% to 80% per lb. of metallic tungsten contained		—	
*Ferro-manganese 80%		—	
,, export		—	

* F.o.b. Liverpool.

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash	136	0	0	136	10	0
Three months	135	10	0	136	0	0
Electrolytic ..	151	0	0	147	0	0
Tough	—			—		
Best selected	—			—		

Tin.

Standard, Cash	215	10	0	215	15	0
,, Three months	215	10	0	215	15	0
English Ingots ..	—			223	0	0
Bars	—			—		
Refined	—			—		

Spelter.

American	55	0	0	52	0	0
Specials..	—			—		
Hard	—			—		
British	—			—		

Lead.

Soft Foreign	30	10	0	29	10	0
English	—			Nom.		

Antimony.

Regulus	—			85	0	0

Aluminium.

Virgin Metal 98/99% per ton	—

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots.. ..	—

CASTINGS.	Per lb.
I. or II.	—
III. IV. or V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
,, Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. 35/- above price of best selected copper.

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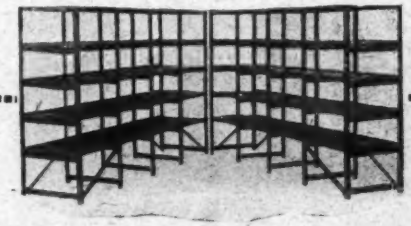

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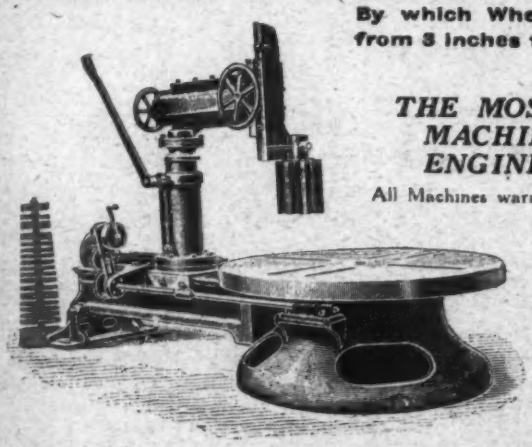

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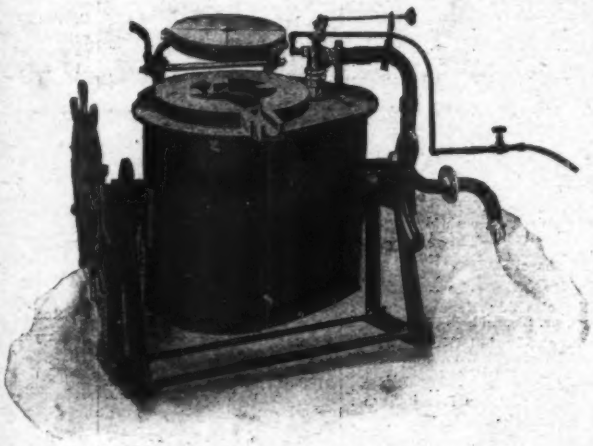

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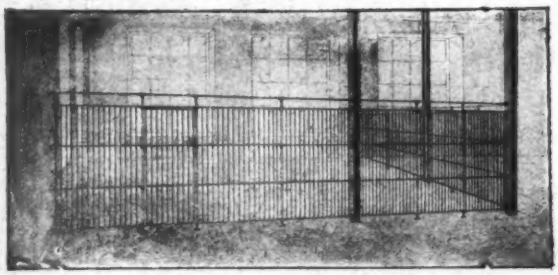

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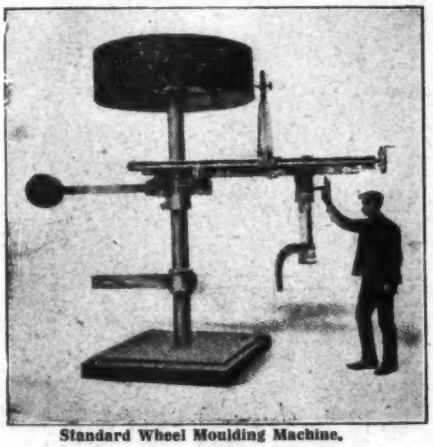

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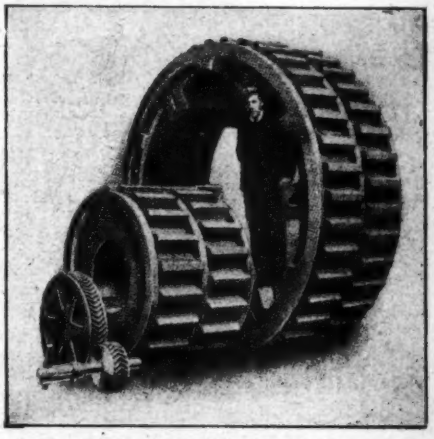

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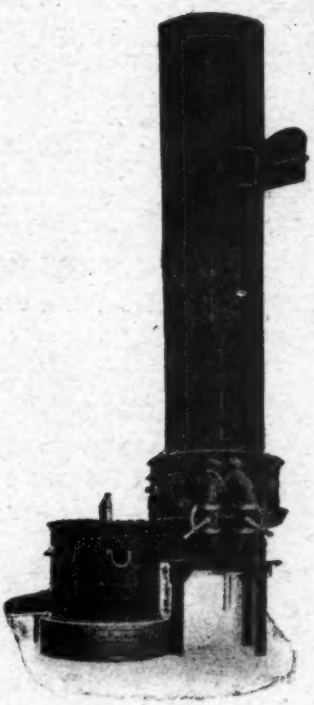

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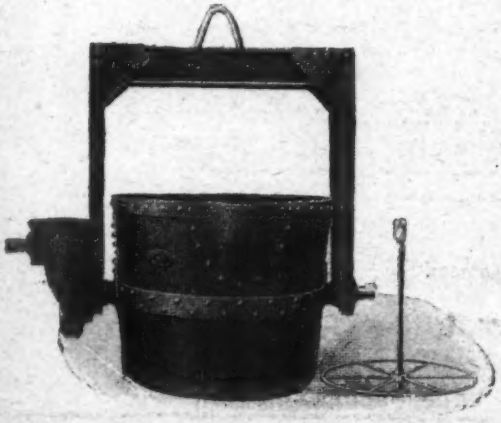

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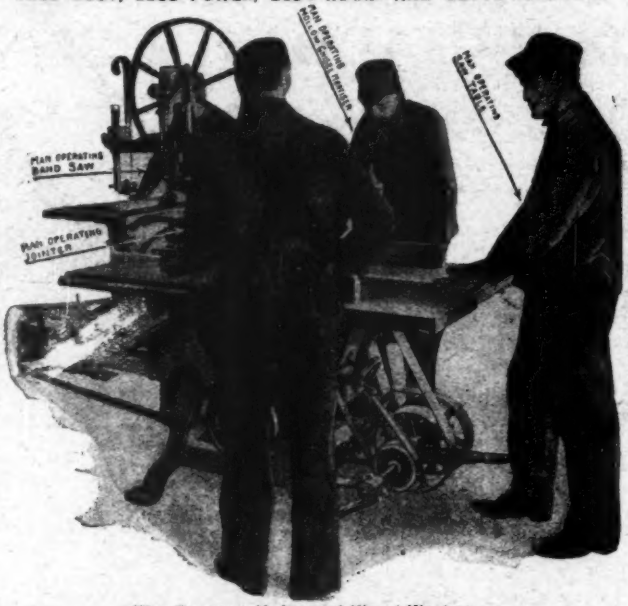

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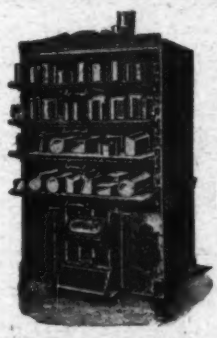

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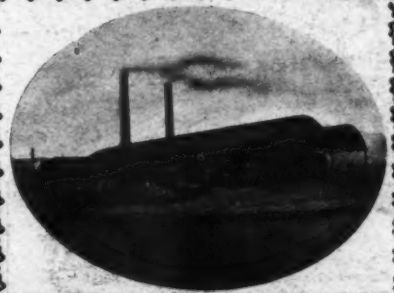

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